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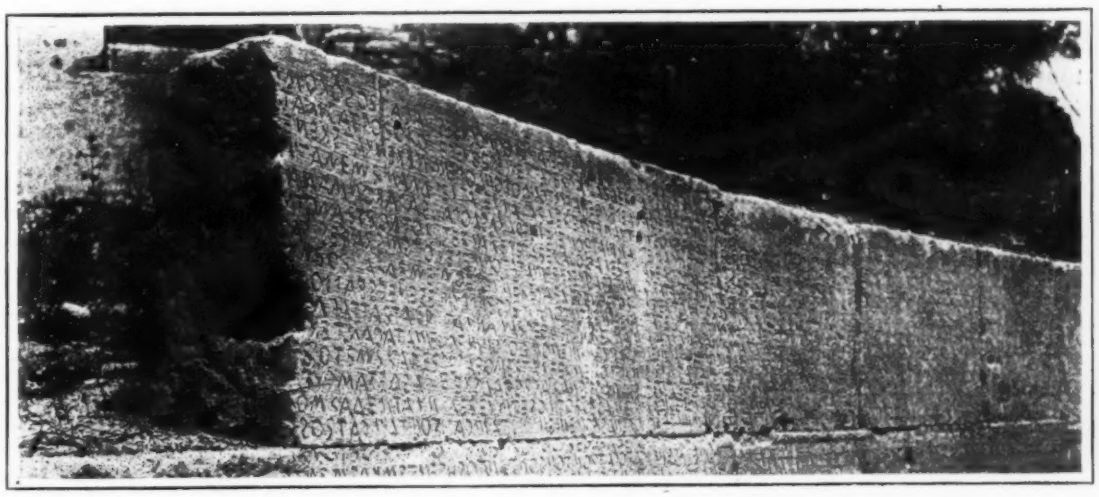
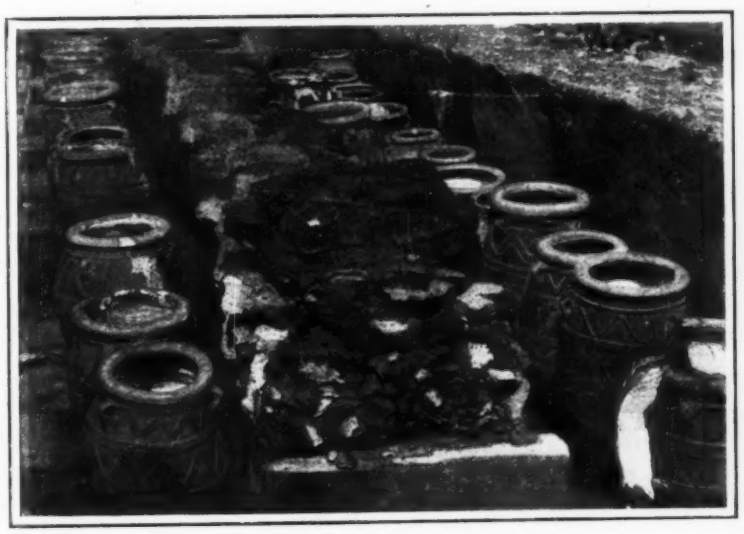
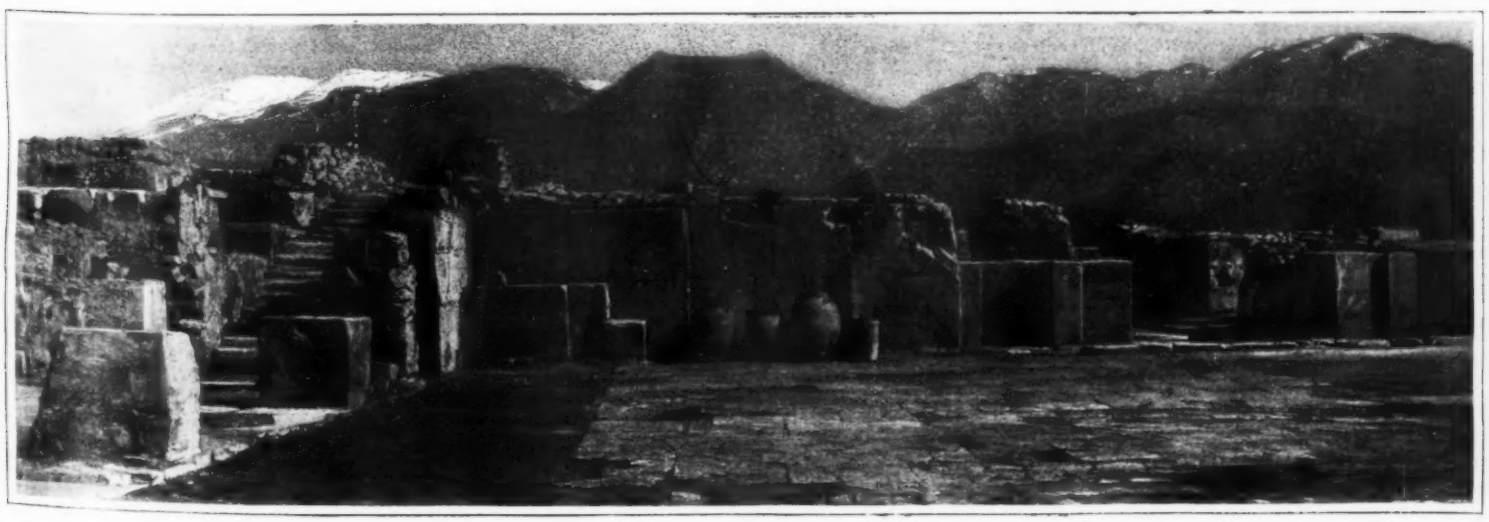


THE TABLETS OF THE LAWS OF GORTYNA.

PALEOKASTRO. THE PRINCIPAL STREET SEEN FROM THE NORTHWEST.



THE STOREHOUSES OF KNOSSOS.



THE RUINS OF PHAESTOS.

EXCAVATIONS IN CRETE.

EXCAVATIONS IN CRETE.

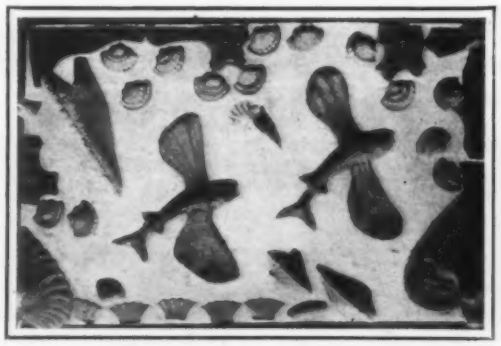
THE WONDERFUL TOWN OF KNOSSOS.

THE commencement of the excavations in Crete, starting from the period when the island was set free and made easily accessible to exploring parties, marks a date in the history of great archæological discoveries. As soon as the country was opened a number of expeditions were sent to the island, among which the American, English, and Italian parties were the most prominent. Among the leading excavation work at Crete may be mentioned the English excavation of Messrs. Arthur Evans, Mackenzie, and Hogarth at Knossos, near Candia, at the grotto of Dikte (Psychro), at Praesos, Paleokastro, and Zakro; the American work carried on at Gournia in the bay of Mirabello; the excavations made by the Italian parties at Phaestos and Haghia Triadha in the southern part of the island. These different finds resulted in revealing an entire civilization, or rather a succession of periods from fifteen to thirty centuries back. To these periods the name "Minoan" has been given, from the legendary King Minos, and the most recent of these epochs, about 1500 B. C., corresponds with the art of Mycenae which at the time of Schliemann's excavations made such a sensation in the archæological world and gave rise to new theories and comparisons. Numerous are the publications about these discoveries. We will at present sum up the leading points regarding them, without touching upon the chronologies, which are of a somewhat too technical order and have not as yet been definitely settled. Owing to the continual finds and the new data which they bring to light it would evidently be rash to establish any very definite theories at present.

In a brief review of the subject we may say that the Minoan epoch, for which archæologists suppose, in a rather arbitrary classification, nine successive periods which correspond with the nine years of King Minos's reign mentioned in the Odyssey, represents in the region of the Aegean sea the bronze age between the neolithic (found at the lower parts of the ground at Knossos) and the iron age. The latter seems to coincide with the Dorian invasion, along with the practice of incineration which was introduced at the time, this being the eleventh century B. C. As to the nine periods of the Minoan epoch, these are the ancient, middle, and recent, and each period is divided into three stages. An essential result from a historical standpoint has been to reduce or set back the rule of the Phenicians in order to bring out a great Minoan civilization, influenced directly by Egypt from the first dynasty, then developing by an independent growth in which writing was already known, but a writing which we are not as yet able to decipher, but which has furnished numerous specimens, contrary to the conclusions which were drawn from the excavation of Mycenae and Troy, these being almost entirely destitute of traces of writing. It is considered at present that the Aegean or Cretan writing was the starting point from which the Phenicians later on took the alphabet by a process of elimination. The Cretans commenced by building vessels on the model of the Egyptians, then took the art of pottery from the latter nation, besides fresco painting and decorative models. But they had a good share of invention in these fields, and the palaces of Crete, which we illustrate here, resemble neither those of Egypt nor of Mesopotamia. At Knossos, the capital of King Minos, where Mr. Evans's excavations have been so fruitful, have been found as in the most of the ancient ruins, at Troy, for instance, several superposed cities representing a series of civilizations whose order we will mention briefly. The first, when were built the palaces of Knossos and Phaestos (later than the ancient Minoan, but still near the neolithic age, although fertile in Egyptian objects) represents the middle Minoan, second stage, characterized by the fine vases discovered in the Kamares grotto on Mount Ida and by a kind of hieroglyphic writing which succeeded the first pictographic signs of the end of the ancient Minoan epoch. On the first

VASES IN THE MYCENIAN STYLE.

of the ruined palaces were rebuilt at the period known as middle Minoan, second stage, the second palaces of Knossos and Phaestos, whose ruins now uncovered are in part shown in the views here presented, and which will be mentioned further. Belonging to this epoch are the curious figures of terra cotta, of which we show two specimens. On each vase is a remarkable statue of a female figure wearing a high head-dress or tiara, with two serpents rolled about the waist and



A BAS-RELIEF FOUND AT KNOSSOS.

also having serpents around the arms. Another figure represents a she-goat suckling her young, and others have the form of shells, fish, also native shells cut out of stone, vases in the form of animals' heads, etc.

Besides, during the period known as recent Minoan, first stage, the town of Knossos furnished some fine bronze vases worked in *repoussé*, while at Haghia Triadha near Phaestos were found (by the Italian parties) some important frescoes and vases of steatite with processions of reapers, figures of warriors, bull hunts, etc., which have overturned all the theories as to the famous Vaphio goblets found near Sparta (perhaps of Cretan origin). At this time the writing became linear and the palaces of Haghia Triadha, Gournia, and Paleokastro yielded tablets which are covered with it. In the recent Minoan, second stage, corresponding to the eighteenth Egyptian dynasty, took place the last building changes made in the palaces of Knossos and Phaestos. To this relatively more recent period are to be naturally assigned the best preserved and most striking parts, such as the halls decorated with frescoes in which are seen processions of persons, bull fights, dolphins, and other fish, assemblies of women in toilets which are surprisingly modern in the drapery and jewels, then the storehouses with their ranges of great vases (see illustration) and near them in a hall which is lighted from the top and provided with stone benches along the walls, a very curious seat with a pointed arch back which seemed most appropriate for the throne of King Minos. Afterward the palaces of Knossos and Phaestos were destroyed by a violent fire (1500 B. C.) which had full scope, seeing that wood was the material for the upper part of the edifices, with considerable use of plaster stone. The hegemony was transferred to the continent, where Mycenae already existed (according to the tombs of the Acropolis, probably at the beginning of the recent Minoan period) but where the greatest progress is to be noted at the end of the above period, corresponding to the eighteenth and nineteenth dynasties. The Mycenian civilization, which is recognized in the excavations by the pottery decorated with plants and animals, dominated from 1500 to 1100 (epoch of the Trojan war, about 1200 B. C.) down to the Dorian invasion, which has been compared to the Barbarian invasion in the Middle Ages. After three or four centuries of this barbaric period, a kind of Middle Ages, we come to a Renaissance whose beginning is marked by Homer about 800 B. C. and which commenced to develop, especially in Greece, a hundred years later.

FAIENCE BAS-RELIEF. GOAT AND YOUNG.

EXCAVATIONS IN CRETE.

It is interesting to see what may be the relation of the myths concerning Crete with the present discoveries. In our mythology we have from Crete first of all the labyrinth, then the bull, which came from the sea and which is connected with the legend of Pasiphae. Hence originated the latter's offspring, the Minotaur, which is overcome by Theseus. Another legend is the birth of Zeus in a grotto on Mount Ida, with the war dances and the noise made by the Curetes striking on their shields so as to smother the cries of the new-born infant and prevent his being discovered by Saturn. Lastly we have the serpents which Minos produces by the magic influence of Pasiphae.

As regards the Labyrinth, two theories are proposed, the first that the visitors to the Knossos palace had simply been impressed by the complication of the narrow passages. Another and more ingenious theory relates to the double ax which is a prominent feature in the decoration. In the Island Greek dialect it was called *labrys*, whence the term labyrinth, or palace of the ax. We find this symbol very frequent, and it is a symbol of Zeus, near which it figures upon a Mycenian gold ring. In Crete it is found alone or with bull's horns, which are another symbol of the god, and seems to be attached to the primitive religious traditions. The Bull of Pasiphae and Europa seems also to come from the Cretan Zeus, taken from the horns so often seen as a native emblem, or from the groups of bulls upon the frescoes. The coins of Phaestos carry on one side a bull and on the other a young deity with a bird (perhaps an eagle) resting on the double ax. With Zeus is also associated the shield of a figure 8 form, which gave rise to the Curetes legend when the original war dance was lost sight of. The serpent legend corresponds to the numerous religious objects on which are found serpents such as statuettes of women and other figures found at Paleokastro holding serpents in the hand, perhaps snake-charmers connected with a religious rite. With such legends and their explanation we can have some idea of the original Cretan religion, without temples, but only chapels in the palaces or grottoes such as the cave of Zeus on Mount Ida. We have the worship of an agrarian deity (bull) giving fecundity, a deity of vegetation to which as at Dodona are consecrated the sacred oaks and which is at the same time a war god (double ax and shield), also a female divinity connected with the earth (mother earth or Demeter) to which the animals are consecrated and which is figured between lions, a dove upon the head and brandishing serpents. As to the cult of the dead, it is shown by burial with the most sumptuous apparel and arms, sacrifice of a bull, and by libations which are made by a woman (on the frescoes) between two wood pillars painted green, resting upon a base of red and white stone and carrying at the top the double ax of Zeus upon which is perched the emblematic bird.

Coming to the actual aspect of the most important excavations, those of Knossos, of Phaestos, and of Paleokastro, we find that on arriving at Knossos by

the east we perceive at the foot of a hill, the substructures of the royal palace with the throne room and in the rear the storehouses. There is a flight of very wide steps, near the northwest entrance, which perhaps were occupied by the king in giving judgments. Then comes a room in whose center is a square pillar with blocks marked with the double ax, and then a large room with four doors; the throne room, and a series of storehouses, with their great oil jars. In other galleries were fine jars decorated with papyrus where were found several hundred tablets with as yet undeciphered inscriptions, these being no doubt inventions. At Phaestos the Italian party uncovered a large palace which is better preserved than that of Knossos and whose picturesque aspect is still more striking. We find wide staircases, halls paved with flag-stones, etc. At two miles from this palace the villa of Haghia Triadha, explored also by Halbherr of the Italian expedition, gave in smaller rooms of a like aspect, a series of well-preserved objects such as steatite cups, a painted sarcophagus, frescoes of singular beauty, magnificent vases with Mycenian palyp decoration, with analogous vases of Zakro, which are the most ancient of the kind as yet known (1500 B. C.). At Paleokastro, a street, which is illustrated, resembles in general appearance the streets of Pompeii. The houses are small and no structure like a palace has been found as yet.

But here exists a temple of Zeus, evidently of a much later period, where has been brought to light a ritual hymn cut in the marble. Of this comparatively recent Greek period (classic archaic period) we illustrate a great inscription of the sixth century B. C. which is very striking, aside from its historic interest. It was found at Gortyna and contains a set of laws relative to marriage, adoption of children, property, etc. The structure when discovered was used as a mill-race.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

SOME FACTS ABOUT DYNAMITE.

THE CHEMISTRY OF A POWERFUL EXPLOSIVE.

DYNAMITE is a mixture of nitro-glycerine (which is a heavy oily liquid) and an absorbent, such as wood-pulp. The mixture is preferable to nitro-glycerine alone, because it can be handled as a solid instead of a liquid, and also because a much heavier shock is required to explode it, thus making it comparatively safe to move. The nitro-glycerine is commonly spoken of by men about the works as the "oil," and the absorbent material is called the "dope."

Explosives are made by obtaining oxygen in some concentrated form and mixing it with a combustible, so that the latter can be burned instantly, without the necessity of obtaining the oxygen for its combustion from a large quantity of air. The gases generated by the combustion and expanded by its heat, give the force to the explosion. Thus black powder is made by mixing charcoal and sulphur, which are combustibles, with niter (potassium nitrate), which is 47.4 per cent oxygen. In nitro-glycerine, the glycerine is the combustible and nitric acid (which is 71.2 per cent oxygen) supplies the oxygen to burn the glycerine.

Glycerine is a combustible, just as wood and coal are. It is made from fat, which when treated with steam under pressure, separates into glycerine and stearic acid (from which candles are made). The explosion of nitro-glycerine is much sharper than that of gunpowder, because the oxygen in it is mixed with the combustible in a much more intimate way. Gunpowder is merely a mechanical mixture in which the particles of combustible and the particles of the oxygen carrier (niter) are lying side by side. In nitro-glycerine, however, the oxygen carrier does not exist as a separate particle, but has been injected into the molecule of the glycerine itself. In gunpowder the separate particles are, say, one thousandth of an inch in size, and therefore the elements must move on an average that far when they unite in combustion. But a molecule is supposed to be only a five billionth of an inch in size, and each molecule contains atoms of combustible material and atoms of oxygen. In fact, the atoms are so very close together that they are almost touching, and if we hit the nitro-glycerine a sharp blow we jar them so that the atoms of combustible and the atoms of oxygen are thrown far enough out of their places to come in contact with each other and an explosion takes place. If we jar all the molecules at the same time, then they all explode at the same time, and the explosion is terribly sharp. But if we mix the nitro-glycerine with some less active material and detonate it at one end, then it takes an appreciable amount of time for the jar to travel to the other end of the mixture and the explosion is not quite so sharp. Thus the explosion of dynamite containing 70 per cent nitro-glycerine is much sharper than that containing 40 per cent; and by using only 5 per cent we make a variety known as "low" powder, which has a lifting instead of a shattering effect, and it is largely used as a substitute for the common black powder.

It is impossible for any one to understand the import of all that is being done in the business without knowing exactly what takes place in the nitrator when glycerine is converted into nitro-glycerine. A molecule of glycerine is composed of 3 atoms of carbon (C), 5 atoms of hydrogen (H), and 3 radicals of hydroxyl (OH). It is represented graphically in Fig. 1, in which each letter stands for an atom. A molecule of nitric acid (which is used to supply oxygen to the glycerine and thus make it combustible) is composed of 1 atom of hydrogen (H), 1 atom of nitrogen (N), and 3 atoms of oxygen (O). It is represented graphically in Fig. 2. What happens to the glycerine when we inject the oxygen carrier into it? First, the radical of a molecule of nitric acid pushes the hydroxyl of the glycerine molecule out of the combination, and we have glycerine mono-nitrate. At the same time the hydroxyl radical that is pushed out unites with the atom of hydrogen that was formerly combined with the nitric acid, forming HOH (or H_2O), which is just ordinary water. The mono-nitrate and the water are plotted in Fig. 3.

Similarly by bringing another molecule of nitric acid to act upon this same molecule of glycerine (or glycerol) mono-nitrate, a second hydroxyl radical can be displaced, forming glycerine di-nitrate and a second molecule of water (Fig. 4). And by acting still more strongly with nitric acid upon the glycerine di-nitrate, we can displace the third radical of hydroxyl, and we then obtain glycerine tri-nitrate (which is ordinary nitro-glycerine) and a third molecule of water (Fig. 5). In the dynamite works the acids are not strong enough to convert all the glycerine into the tri-nitrate, and some of the glycerine never gets beyond the di-nitro stage. In a manner similar to the manufacture of nitro-glycerine we can inject our oxygen carrier (nitric acid) into other combustible materials such as cotton, wood-pulp, starch, phenol (carbolic acid), and naphthalene; thereby forming gun-cotton, nitrated wood-pulp, tetra-nitro-starch, picric acid, and di-nitro-naphthalene. These and many other nitro-compounds are explosives like nitroglycerine, but they possess some quality which unfits them for miner's use, although employed in military and sporting powders.

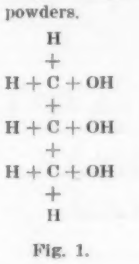


Fig. 1.

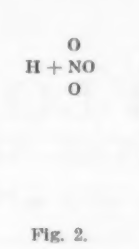


Fig. 2.

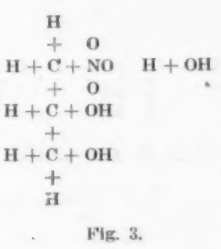


Fig. 3.

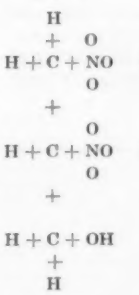


Fig. 4.

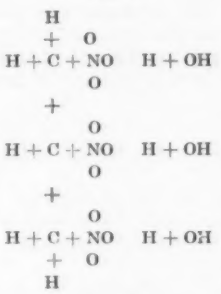


Fig. 5.

Fig. 1.—Glycerine.

Fig. 2.—Nitric acid.

Fig. 3.—Glycerine mono-nitrate + 1 molecule water (H + OH).

Fig. 4.—Glycerine di-nitrate + 2 molecules water.

Fig. 5.—Glycerine tri-nitrate (nitro-glycerine) + 3 molecules water.

Now look again at our map of a nitro-glycerine molecule (Fig. 5) and you will understand why nitro-glycerine can be exploded by a shock. On the left side are atoms of hydrogen and carbon, which are both inflammable. On the right side are nine atoms of oxygen, more than enough to burn up all the carbon and hydrogen atoms. Between the oxygen and the combustible atoms, preventing them from coming in contact, are three atoms of nitrogen (N). But if you jar the nitro-glycerine by a sharp blow, such as the stroke of a hammer or the explosion of detonating cap, then the oxygen atoms get shaken out of that fine acrobatic balance they have been in, and coming in contact with the combustible atoms, the latter all burn up instantly. The hydrogen atoms combine with the oxygen atoms to form water (steam), H-O-H, the carbon is burned to carbon dioxide (carbonic acid gas) O-C-O, while the nitrogen is set free as hot nitrogen gas. The liberation of these three gases in the small space formerly occupied by them when they were nitro-glycerine, expanded still further as they are by the heat of the combustion (temperature 5,700 deg. F.) gives the disrupting force of the explosion.

The dope for ordinary dynamite consists of wood-pulp (such as is used in the manufacture of paper), which is used to absorb the nitro-glycerine; precipitated carbonate of magnesia, which is added to neutralize any possible acidity in the nitro-glycerine or any acidity which might develop in the powder during storage and perhaps cause a spontaneous explosion; in some grades a little flour ("middlings") is used; and there is a liberal allowance of ground sodium nitrate (Chile saltpeter) for the purpose of oxidizing the wood-pulp and "middlings." It forms with them an explosive analogous to gunpowder.

The essentials of a good powder are that the nitro-glycerine must have been washed entirely free of all acidity, and must contain a minimum of moisture, which, in the higher grades, may cause the nitro-glycerine to exude. The powder should contain a liberal supply of niter for the purpose of thoroughly oxidizing the wood-pulp and "middlings" present to water and carbon dioxide. Carbon monoxide is much more deleterious in a mine than the dioxide. And lastly, what is generally considered most important of all, the powder should be mixed and packed to the proper consistence. In theory the most perfect explosive would be made if the niter were ground very fine, so as to make an intimate mixture with the wood pulp, but in practice such fine grinding seems to give less satisfaction. The powder is apt to pack into hard sticks in the packing machines, whereas the men I have worked with in the mines have always preferred a medium consistence, so that the powder will tamp well in the drill-hole. I give below the formulas for the principal grades of ordinary dynamite:

	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Nitro-glycerine	70	60.0	50	40.0	30.0
Wood-pulp	20	16.5	14	11.2	4.2
Ground sodium nitrate	7	22.5	35	46.2	60.0
"Middlings"	..	....	..	2.2	5.8
Precipitated magnesium carbonate	3	1.0	1	0.4	....

In the 70 per cent grade a little of the nitro-glycerine occasionally exudes upon the wooden packing case; therefore it is always well for miners to handle the 70 per cent cases more carefully than the other grades, which never possess that fault.

Gelatine dynamite is a variety that has gained greatly in popularity in the last few years. It is made by mixing a little "soluble" gun-cotton with the nitro-glycerine, the gun-cotton having the property of turning the nitro-glycerine to a jelly. The "dope" is then added, about the same as for ordinary dynamite. Gelatinized nitro-glycerine is almost as waterproof as rubber and when placed under water it will not separate from its "dope" as plain nitro-glycerine does. On account of its jelly-like consistence it is particularly valuable for tamping into "upper" holes in wet mines.

The latest variety of dynamite is an improved form of ammonium dynamite. Ammonium nitrate is both an oxygen carrier and a substance that is easily decomposed into gases, without leaving any solid residue, as sodium nitrate does. The difficulty of using it has been that it is strongly hygroscopic, that is, it attracts moisture from the air, just as kitchen salt does in a more moderate degree. To give an idea of its composition I will quote one of the Kennedy-Neilson formulas:

	Per cent.
Nitro-glycerine	25
Nitrate of ammonia	20
Wood-pulp	15
Nitrate of soda	40

This dynamite is equivalent in strength to an ordinary dynamite having 40 per cent nitro-glycerine, and it can be manufactured for about one cent less per pound—not allowing for any patent royalties.

Nitro-glycerine is a poison and acts on the system when used either externally or internally. Dissolved in alcohol it is known as "spirits of nitro-glycerine," or glonoin, and is officinal in the pharmacopoeia. It is used in minute doses for stimulating the action of the heart. A headache may be obtained from nitro-glycerine in three different ways. If it is brought in contact with the skin, some of it is absorbed into the blood, generally producing a violent headache, which often lasts as long as three days. The same result follows with some men if they breathe the slight fumes that arise from nitro-glycerine, especially when it is standing in the separators.—Condensed from a series of articles by Whitman Symmes, in the Mining and Scientific Press.

A SELF-PROPELLING SEARCHLIGHT.*

AN EXCEPTIONAL TYPE OF MOTOR VEHICLE.

BY L. RAMAKERS.

A MOTOR vehicle of an exceptional type was built the past spring for the Volunteer Tyne Division, Royal Engineers of England. Since completion, this outfit, which comprises an automobile searchlight, has been severely tested, and has proved a distinct success. With the exception that the original twin 3-inch tires, fitted to the back wheels, had to be changed to twin 5-inch, no alterations were necessary. During the recent naval maneuvers it rendered special service at Portsmouth and Stokes Bay, and was again useful in field work at Salisbury during night attacks. Its utility has also been fully demonstrated at Aldershot, and it is now stationed at Cliffords Fort, North Shields, the headquarters of the Tyne Division of the Royal Engineers. The chassis is built of steel channels with the necessary cross members of the same dimensions; the wheels are 34 inches in diameter, the gage 4 feet 8 inches, and the wheel base 12 feet.

A SELF-PROPELLED SEARCHLIGHT FOR ENGLISH ARMY USE.

The propelling engine is a four-cylinder 18-horse-power "Brooke" with low-tension magneto and high-tension electric ignition, driving through a leather-lined cone clutch to a 3-speed gearbox giving 12 miles per hour at top speed. The generating dynamo, giving 200 amperes at 80 volts, is coupled direct to a four-cylinder 35-horse-power "Brooke" motor, also having duplicate ignition and cooled by a large independent honeycomb radiator with a large fan.

The gasoline supply is carried in two large circular tanks, one at each side of the car. These are so arranged in duplicate, as is the whole outfit, that the light can be kept running from one tank while the other is being filled. This also applies to accumulators, strainers, pressure valves, pressure pump, etc.; the advantage of the two separate engines is evident, for while the vehicle is traveling the generating engine can be adjusted, and when this engine is in operation, any necessary adjustment can of course be made to the propelling engine. The projector itself is of the hand-feed type, 36 inches in diameter (the largest size used).

A spare lens, as will be noticed, is carried in a frame between the dynamo and projector. We are informed that in future, outfits of this type are to be improved, insomuch as the projector is being carried in a trailer that can be detached and placed in otherwise inaccessible positions. A center core cable drum is to be carried on the main equipment, and in addition a distributing board will be provided, in order that two or three 18-inch projectors may be used instead of the one of 36 inches diameter.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

A NOVELTY IN FLOATING CRANES.

AN IMPROVEMENT ON THE SHEAR LEG DESIGN.

BY F. C. COLEMAN.

ON account of the great proportions of the "Mauretania" of the Cunard Line, her builders, Messrs. Swan, Hunter & Wigham-Richardson, were obliged to make very special and elaborate arrangements for the fitting of the boilers and machinery into the vessel, and for this purpose they had delivered to them a powerful floating crane, built by Messrs. Beecham & Keetman at their works at Duisburg on the Rhine, and which is illustrated in the accompanying photograph. The shear leg construction has previously found most favor in the design of floating cranes. Under this system the feet of the fore legs are at the pontoon gunwale, and the load passes between the legs. This arrangement has, however, certain disadvantages, the chief of which may be thus enumerated: (1) The loads to be handled must not exceed certain dimensions, limited by the sloping position of the fore shear legs; (2) the outreach of the crane from the turning point of the legs to the middle of the hook cannot be used to its full extent, for even at a small inclination the legs will come in touch with the side of high ships; (3) the legs become clumsy and expensive, owing to their great length. In the 140-ton floating crane illustrated herewith, these drawbacks are overcome; for the turning points of the jib are kept so far back from the pontoon gunwale that sufficient space is left in front of them for taking up the goods, and therefore the load, being no longer passed between the crane legs, need not be of restricted dimensions. Masts, chimneys, and other long parts of a vessel may easily be fitted with the help of a crane of this design, while similar operations are often extremely difficult, and sometimes impossible, with the usual shear-leg type of crane. The crane barge can lie close alongside of the ship, and the jib, as far as the screw spindles permit, may be adjusted toward the outside. The big hook of the 140-ton crane has a maximum outreach of 78 feet 9 inches, and the 200-ton hook one of 98 feet 5 inches, measured from the middle of the hook to the turning point of the jib. The smallest radius is 8 feet 10 inches and 15 feet 9 inches respectively. The lifting gear for the large hook still carries 80 tons at the greatest outreach of 78 feet 9 inches and 140 tons at 55 feet 10 inches radius. At a breadth of the pontoon, 75 feet 6 inches, a free space about 24 feet 6 inches broad remains on deck in front of the jib, in order to ship the articles. The motion of the engine shaft of the twin steam engine is conveyed to the main shaft by means of a pair of spur wheels. Three change gears of the builders' own design, and corresponding to the three lifting gears, are arranged on this main shaft. The bevel wheels of these change gears are made of Krupp's close-grained cast steel. These bevel gears have proved very satisfactory in numerous other installations, and insure a safe working of the crane. The following are the working speeds attained: Large hook, lifting of loads to 70 tons 6.56 feet per minute, lifting of loads from 70 to 140 tons 3.28 feet per minute (test load 175 tons); small hook, lifting of loads to 10 tons 49.4 feet per minute, lifting of loads from 10 to 20 tons 24.7 feet per minute. The large hook carries the loads in ten falls of rope, the small hook in four falls. The lifting ropes have a safety factor against breaking of 8 to 10. Each lifting gear permits of both ends of the rope being wound up simultaneously, for which purpose the lifting gears are equipped with two separate rope drums. The hooks are arranged on ball bearings, and are easily movable. The hook for the 140-ton load is of a special construction, and is provided with two joints. Each lifting gear is fitted with a brake.

A NOVELTY IN FLOATING CRANES.

A further independent lifting mechanism is located on deck of the barge between the sides of the protecting frame. This lifting gear, driven by a special reversible twin-screw engine, actuates a small crab of

5 tons lifting capacity. The track of this crab is arranged underneath the jib from the knee to the top of the crane nose, and has therefore a length of 56 feet. The purpose of this arrangement is the shipping of small loads from the deck of the pontoon, or from a skute lying between the pontoon and the ship, without having to adjust the jib.

The pontoon carrying the crane has a length of 90 feet 6 inches, a breadth of 78 feet, and a height on side of 12 feet 6 inches. All the material used for the hull is Siemens-Martin steel, in accordance with the conditions of and tested by the German Lloyd. Two longitudinal bulkheads, passing through the whole length of the ship, and at the same time carried out as crane foundations, and two further cross bulkheads, divide the pontoon into nine compartments, the two aft ones being used as ballast tanks. The middle room contains four vertical, non-condensing, two-cylinder compound engines, all these being employed for propelling purposes, while two of them are for the thwartship motion.

The pontoon is steered by two rudders, the tillers of which are connected with each other by means of a coupling rod. These rudders are actuated from the raised bridge by the aid of a winch with hand gear. Warping is effected with the help of four steam capstans, each of 3 tons traction effect.

HOW TO CONSTRUCT A SIMPLE WIRELESS TELEPHONE.*

AN APPLICATION OF ELECTRO-MAGNETIC INDUCTION.

BY A. FREDERICK COLLINS.

THERE are several methods known by which articulate speech can be transmitted between two given points without connecting wires, or wireless telephony, as it is popularly termed.

Among the most important methods may be cited the following: Those operating (1) by electro-magnetic induction, (2) by electric current dispersion, (3) by

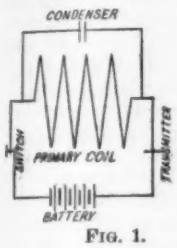


FIG. 1.

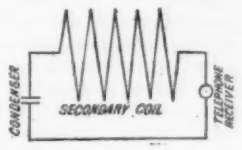


FIG. 2.

SIMPLE INDUCTION SYSTEM OF WIRELESS TELEPHONY.

variation of a beam of light, (4) by electro-static induction, and (5) by electro-magnetic waves.

The first method, namely, that of electro-magnetic induction, is the simplest of all those above enumerated and will not only serve in an experimental capacity but will as well be useful in demonstrating to the layman that the human voice can be transmitted and received through space without connecting wires, and even though walls and other objects intervene the transmission will not be appreciably affected.

The fundamental principle upon which the electro-magnetic induction wireless telephone is based is the same as that involved in the induction coil, in that the energy of a primary electric current is transposed into magnetic lines of force, and these are retransposed into secondary electric currents. The apparatus for telephoning without wires is likewise similar to an induction coil for it comprises two windings, the primary serving as the sending coil and the secondary as the receiving coil. Its action consequently is similar to that of an induction coil, for when the primary winding is energized by means of an undulating current it will be instantly surrounded by magnetic flux in the form of lines of force that spread out in ever expanding and contracting circles at right angles to the direction in which the primary current is flowing.

At the instant the lines of force emanating from the primary coil impinge upon and thread through the turns of wire of the secondary coil the electro-magnetic energy is converted into electric currents and an electro-motive force is set up that is proportional to the rate at which they intersect the turns of wire of the secondary coil. If the primary and secondary windings are built up in the form of an induction, that is with the secondary coil wound closely around the primary coil and on the outside of it, there will be a comparatively small loss of energy in the successive transformation and in this design the inductive effects will be a maximum.

Now it is possible to design an induction coil so that the primary winding will transform the energy of the electric currents flowing through it into magnetic lines of force that will not be confined to the immediate proximity of the coil itself but conversely will be transmitted to considerable distances, and if a secondary coil is placed in the field of force—which may have a radius of fifty feet or more—then induced currents will be set up within it, the amount of energy it receives depending, of course, upon a number of factors, the chief ones being the amount of energy impressed upon the primary coil, the diameters of the

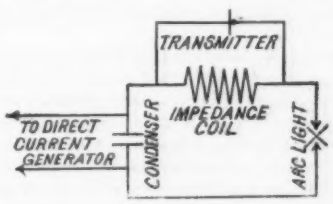


FIG. 5.—DIAGRAM OF SPEAKING ARC.

primary and secondary coils, the number of turns of wire forming the primary and secondary coils and finally the interval of space separating the primary and secondary coils.

It is not the writer's intention to enter into a consideration of all these factors, as the laws governing them may be found in nearly all elementary text-books on electricity and magnetism, but it is my purpose to describe the construction of a simple wireless telephone that will give results up to thirty or forty feet and which will operate through ordinary walls without any appreciable loss of energy.

The transmitter in its simplest form consists of a source of electromotive force, a primary coil of wire called an inductor, and a telephone transmitter, all of which are connected in series; the receiver comprises a secondary coil of wire and a receiver, a wiring diagram being shown for the entire apparatus in Figs. 1 and 2.

To construct this demonstration wireless telephone the first move is to procure the necessary materials. The source of electromotive force should be considered first. A battery of dry cells, since this is usually most easily and cheaply obtained, may be used for energizing the primary coil, but as the drop in voltage and current is excessive the result can never be highly satisfactory; if dry cells are utilized ten or twelve should be coupled in series and exceeding care must be taken to cut off the current, by means of a switch, the moment the operator has ceased speaking.

A bichromate of potash battery of six or eight cells will provide a much more suitable means for supplying the initial current, although this must be looked after with considerable care. Better than either of the preceding is a 110-volt direct current where this can be obtained, when the distance between the sending and receiving instruments may be greatly increased; where the current is taken from a lighting circuit is must, of course, be cut down by a resistance to a value where it will not burn out the transmitter.

Where a battery is employed to energize the primary coil then the transmitter used in connection with it should be adapted for a low voltage, say six or eight volts, but where the current is derived from a lighting circuit the transmitter should be capable of carrying twenty-five volts. Transmitters for these voltages can be purchased in the open market, and for heavy current work the type known as solid-back transmitters work best.

Having arranged for the current and provided a suitable transmitter the next step is to wind the

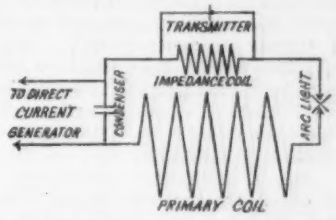


FIG. 6.—SPEAKING ARC TRANSMITTER WITH SENDING APPARATUS.

primary coil. The diameter of the coil may be as large or as small as desired, but it must be borne in mind that the larger the coil—everything else being equal—the greater the transmitting distance. The diameter then must be more or less arbitrarily fixed unless we have determined beforehand the distance to be covered and the various other factors in the case. For the experimental set under consideration the coil may conveniently have a diameter of about three feet and should be formed of approximately two pounds of double cotton-covered magnet wire, No. 16 or 18, American wire gage, and wound in a circle.

The easiest way perhaps to wind a coil of this diameter is to describe a circle on the floor or a wall of the diameter required. Around the circle at intervals of six inches or so wire nails should be driven to a depth sufficient to make the projecting portion rigid. Around these nails the wire is wrapped not too tightly but taut enough to prevent it from coming off when the additional turns are put on. After the wire is formed into a coil it may be further insulated by giv-

FIG. 3.—THE TRANSMITTER.

FIG. 4.—THE RECEIVER.

ing it a coat of paraffin—previously melted and in a hot fluid state—applying it with a brush.

This done, enough of the nails are withdrawn to permit the coil to be removed, when the turns of wire may be further secured in place either by covering the coil with adhesive tape, such as electricians use, or by taping with strips of muslin cut in one-inch

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

widths and wound around the turns of wire diagonally; after each section of the muslin tape is put on it is coated with the hot paraffin. This completes the three absolutely necessary parts of the transmitter and its combination is ready to be set up. The coil can be mounted on a wall together with the transmitter and the battery set on the floor, when the different parts are connected up, as shown in Fig. 1, or what is very much better both as a matter of appearance and portability is to make a neat box, say 6 inches wide, 6 inches deep, and 8 inches in height; this box should have either a hinged lid or a lid that is screwed on; the box is then mounted on a camera tripod which can be purchased at photographic supply houses for 75 cents or thereabout.

The transmitter can then be screwed to the front of the box, while the primary coil is sustained in position by placing it over the box, as shown in Fig. 3. The terminals of the battery, the transmitter, and the coil are connected in series either by means of binding posts attached to the box or by leading the terminals of these devices inside the box and there soldering them together.

The receiving coil may have the same diameter as the transmitting coil and is wound with two pounds of No. 25 double cotton-covered magnet wire paraffined and taped as in the case of the primary coil. Prior to taping it is well to cut two lengths of flexible insulated wire, say No. 14 or 16, and soldering these to the ends of the secondary coil of wire in order to prevent the latter from breaking off. In soldering, acids should not be used, but after scraping the ends bright rosin should be used as a flux for the solder.

Like the transmitter, it is well to mount the receiving coil and the telephone receiver on a box of the same size as that indicated above and which is supported on a camera tripod, as shown in Fig. 4, when a neat, compact, and portable instrument results, though if this is thought to incur too much additional expense the coil and receiver may be mounted on a wall. An ordinary telephone receiver can be used, though better articulations and longer distances can be bridged by the higher grades of receivers. The inductive effects may be further accentuated by shunting across the transmitter a paper condenser having a fixed value of one-half microfarad and cutting the middle convolution of the secondary coil and connecting in a one-microfarad condenser in series.

The apparatus as described for sending and receiving articulate speech is designed to be used to talk in one direction only, that is, the person who is speaking cannot receive and the person who is receiving cannot talk back. This might be a decided advantage under some circumstances; but if the amateur constructor wishes his instruments to "talk both ways," then two sets of coils will be required at both ends. It must be understood that the sending and receiving coils must always be kept in the same place; that is, they may be set vertically with their planes in parallel, or vertically with their planes in alignment, or horizontally with their planes in parallel or in alignment, but never with the plane of one at right angles to the plane of the other. Signaling attachments can be provided and bells rung by means of Hertzian waves; the construction of a simple wireless telegraph set has been explained in the SCIENTIFIC AMERICAN in the issue of September 14, 1901, and can easily be adapted to the needs of the wireless telephone equipment.

There are many other interesting experiments that can be performed by means of a pair of these coils; for instance, by substituting an interrupter for the wireless telephone transmitter in the primary coil and metallic handles for the telephone receiver and then bringing the coils somewhat closely together shocks may be produced though a wall intervenes. Again, with the same transmitting arrangement and using a small incandescent electric lamp joined to the terminals of the secondary coil the lamp may be made to glow, etc.

In the transmission of speech the current is obviously limited by the transmitter; the best of the type known as the solid-back will not take more than one-half an ampere and 25 volts. To increase the amount of initial energy a "speaking arc" can be utilized to advantage. The speaking arc, or as R. A. L. Snyder has named it, the "arcophone," is an electric arc light that acts as a telephone receiver and reproduces articulate speech. The speaking arc can be produced by an ordinary hand-feed or hot-wire arc lamp worked on a 110-volt direct current and in series with the lamp is an impedance coil. This coil is shunted by an ordinary solid-back transmitter and the lamp and coil are shunted by a condenser, as shown in Fig. 5.

The negative carbon is solid, while the positive carbon is cored; that is, it is impregnated with foreign substances to produce a longer and more uniform arc. The size of the wire for the transmitting coil, where a speaking arc is used, should be increased to No. 10 and there should be not less than twenty-five turns of wire wound in a coil, say five feet in diameter. A rheostat in the circuit should be employed to regulate the resistance until the proper working value of the current is obtained. A wiring diagram for the arc transmitter is shown in Fig. 6.

The same receiving coil may be used in connection with the arc transmitter as that indicated for the smaller set. With an arc transmitter having a five-foot coil and a receptor with a three-foot coil speech may be carried on to distances of one hundred feet or more.

AUTOGENOUS WELDING OF METALS.*

APPLICATIONS OF THE OXY-HYDROGEN AND OXY-ACETYLENE FLAMES.

BY ERNEST SCHNEIDER.

THE newest process in the line of welding metals is autogenous welding in its two varieties; on the one hand with hydrogen and oxygen, on the other with acetylene and oxygen.

In the old fashioned manner, the two pieces to be welded were heated in the smith's fire and then hammered together. For sheets of from 8 to 50 millimeters equaling 0.28 to 1.87 inches thick, welding by means of hydrogen has been employed, but has had no very extended introduction, as the cost of the apparatus for producing the gas and that for the welding machinery was too great.

Many attempts have been made to weld by electricity. Welding with the electric arc consists in forming one pole by the piece to be welded, while the other consists of a carbon rod run along over the line to be welded; this effecting a melting together of the edges. The disadvantage of this method is that the weld becomes glass hard and cannot be worked. Later, instead of carbon, an iron rod has been used as a counter pole.

A good weld may be obtained with the Zerener apparatus. The two poles stand in an acute angle to each other, and the arc is diverted by a magnet, so that it acts like a blow-pipe flame.

All the electric-arc welding processes have the common disadvantage, that they injure the eyes and the portions of the skin that are not protected.

In the "resistance" electric welding process, the piece to be welded is dipped in an alkaline solution; the passage of the current raises it to welding heat, which causes the junction.

Another process, which has shown itself to be better, is that of Thomson. The pieces to be welded, being laid together, make so great a resistance to the current, that the desired temperature is soon reached. The pieces are then pressed together by levers, after the current has been cut out. This process, however, calls for a very expensive plant.

The Goldschmidt "thermit" process is very well known; but it has shown itself adapted only to special cases, and does not seem to have been adopted for general machine-building.

The foregoing are the best known and most important of the older welding processes.

The newest in this line is autogenous welding. There are two different processes under this head; that with the oxyhydrogen flame, and that with the acetylene-hydrogen flame.

Under the first there are also two methods of procedure. In one case hydrogen and oxygen are purchased compressed in reservoirs; in the other, both gases are produced at the place of using, by electrolysis of water.

The oxygen which is bought in compressed form in steel flasks, is usually manufactured by fractional distillation of liquid air obtained by the Linde apparatus, while the hydrogen is delivered by chemical works. In the decomposition of alkalies there is set free a great quantity of hydrogen which was formerly let escape; but nowadays it is compressed and sold.

Oxygen and hydrogen are compressed to a pressure of 120 to 150 atmospheres. As the gases can be used at the burner only at a pressure of ½ to 2 atmospheres, reducing-valves must be employed. That for the oxygen has a right-handed thread, and is painted black; that for the hydrogen has a left-handed thread, and is painted red, so that no mistake can be made.

If the pressure has been reduced to the desired point, the gases can be led to the welding burners by rubber tubes. The oldest construction of burner is that of Daniell. In this the gases were led to the burner separately and mixed only directly before being burned. Tests show that the heat of the flame is dependent on the intimacy of the mixture; this is attained, however, only by mixing the gases a longer time before burning them.

One construction, now much used, allows the gases to enter the interior of the burner tubes in two streams, and meet each other at an acute angle. By this, the gas which has the highest pressure draws the other after it, so that "striking back" of the oxygen into the hydrogen reservoir, or the converse, is impossible, even when the reducing-valves have not been properly closed. The gases, being mixed, are burned in a jet, the diameter of which depends on the composition of the mixture. The more oxygen employed, the greater is the inflammability and quickness of lighting the gases. But the velocity of exit of the gases must be greater than that of kindling; otherwise there would be a "striking back" of the flame. The rapidity of exit determines the diameter of the jet. In order to lower the rapidity of kindling, which may reach 100 meters or 328 feet, per second, the proportion of the two gases is four to five volumes of hydrogen to one of oxygen. With this mixture there is produced a temperature of 1,900 deg. C. = 3,452 deg. F.

But in order to weld, oxidation must be avoided; that is, the flame must have a reducing action. This, however, is effected by means of an excess of hydrogen. The theoretical mixture of two parts of hydrogen to one of oxygen is practically inadmissible.

In order to weld, the parts are brought together butting, the gas is lighted at the burner and the blow-pipe-like flame made to play on the line of weld. The iron commences to melt; the edges are melted together; and this is practicable up to a thickness of 3 millimeters equal to say 0.12 inch.

Thicker sheets than this require the edges to be scarfed and the joint to be filled by a piece of wire which is melted in the flame. In this way it is possible to weld not only lengthwise seams, but the most complicated articles.

An interesting example is the Heizmann superheater, which consists essentially of two iron plates, which are first connected by short pieces of tube and are riveted together on the edges. These tubes were formerly rolled in. But as the expanded ends of the tubes always became leaky, they are now welded autogenously; and experiments have shown that the process is better and cheaper than expanding with a roller.

A very important application of autogenous welding is found in rolled and drawn work, where it is necessary to improve faulty places, and in enamel work, to weld on the spouts and handles of tea and coffee-pots, etc. Not only iron, but also copper, tin, platinum, etc., can be so welded.

The great disadvantage of the hydrogen process consists in the fact that it is suitable only for sheets 6 millimeters, or say 0.24 inch, thick; as for thicker sheets the cost rises too rapidly. However, 40 per cent of the cost may be saved by previously warming the pieces in a coke fire. But above a certain thickness, welding by this process is practically impossible; for such work it is better to employ the oxy-acetylene flame.

The cost of welding by the oxy-hydrogen process is given by the author as follows:

Thickness of sheet.	Oxygen.	Hydrogen	Labor.	Total.
0.5 mm.	4pf.	3pf.	4pf.	11pf.
1 mm.	4pf.	5pf.	5pf.	14pf.
2 mm.	10pf.	12pf.	8pf.	30pf.
3 mm.	20pf.	25pf.	10pf.	55pf.
4 mm.	36pf.	42pf.	14pf.	92pf.
5 mm.	62pf.	80pf.	18pf.	160pf.
6 mm.	120pf.	178pf.	22pf.	320pf.
7 mm.	175pf.	300pf.	25pf.	500pf.
8 mm.	225pf.	400pf.	30pf.	655pf.

The hydrogen process with electrically-produced gases is carried out just as in the last case; only the gases are not taken from steel reservoirs, but made by electrolysis from water, which in large establishments results in a material saving.

The electrolytic apparatus consists of a large vessel with bell-shaped holders in which there are iron electrodes. The vessel is filled with a soda or potash lye. The gases produced by the electrolysis in these holders are led by pipes to two gas-holders; that for the oxygen having half the volume of that for the hydrogen. As sometimes the current is reversed and hydrogen might get into the oxygen holder, and *vice versa*, there are check valves in the pipes and burners to prevent striking back of the flame into the gasometers. The gases are delivered to the gasometers at

* Abstracted from a paper read before the technical department of the Workmen's Union, Chemnitz, Germany.

about 50 millimeters, or say 2 inches, water pressure, so that reducing-valves are not necessary.

The burners are the same as for the last processes, and the entire work is the same. There is, however, the disadvantage that either oxygen must be set free into the air, or some hydrogen must be bought to supply the surplus necessary to cause a reducing flame. [The translator begs to say that a more practical way might be to compress the excess of oxygen and sell it.]

The cost of welding is less than where compressed gas is bought; but the plant is expensive—it may cost from 1,000 to 100,000 marks, or say from $238 to $23,800.

A very important establishment gives the cost of working with electrically-produced gases as follows:

Welded seams made per day.	Thickness of sheets.	Cost of gas.	Total cost per meter of welded seam.
100	0.5 mm.	3 to 6 pf.	6 to 11 pf.
100	1	3 to 7	10 to 14
100	2	12 to 14	19 to 24
100	3	20 to 23	30 to 37
20	6	70 to 80	100 to 150

The Fouché process with acetylene and hydrogen is the latest in this line. About ten or eleven years ago, as acetylene became known [produced by Berthelot, who has just died.—Translator] the industrial world was certain that it would find important applications in the useful arts when employed in combination with oxygen; but the technical difficulties were great. In employing the Daniell burners there was formed at the mouth of the jet, by reason of the high percentage of carbon in the acetylene (92.3 parts by weight) deposits of graphite. When, however, the gas was mixed in the interior of the burner, the unexampled swiftness of kindling of the acetylene-oxygen mixture prevented the employment of such burners. There was always striking back of the flame, as the speed of kindling was 1,000 meters, or 3,280 feet, per second. After this, acetylene was employed under high pressure, as with hydrogen and oxygen, but with little success.

At last the Fouché burner enabled the employment of acetylene under the ordinary pressure at which it is usually produced.

In this welding process the acetylene is, with the aid of a very fine injector in the interior of the burner, drawn from the gasometer by the oxygen under a pressure of one to two atmospheres, so that the mixture enters the jet at the required velocity. This is possible only because the oxygen is in greater quantity than the acetylene, the purpose of which is to prevent striking back of the flame.

One cubic meter = 35.32 cubic feet of acetylene produces in burning 14,340 calories. At the beginning of combustion the acetylene is decomposed into its elements, carbon and hydrogen, and in this dissociation alone it produces 2,600 calories. The rest of the heat is set free by the combustion of the carbon to carbonic acid, and of the hydrogen to water vapor.

In theory, one volume of acetylene requires for its perfect combustion 2.5 volumes of oxygen. The flame must, however, have a reducing action; there must be for every volume of acetylene 1.7 of oxygen.

There thus results a flame composed of an ordinary short blow-pipe flame and a large secondary one. The first one is the place of dissociation of the acetylene into its components. It has a temperature of about 3,000 deg. C., equal to 5,432 deg. F., and consists only of carbonic oxide and pure hydrogen; both of these being reducing gases. With this short flame the welding of the metal is effected without oxidation.

Welding by acetylene has important advantages over that with hydrogen, as one cubic meter = 35.32 cubic feet of hydrogen produces in burning only 3,091 calories. Therefore we have for acetylene and oxygen:

$1 + 1.7 = 2.7$ cubic meters, = 14,340 calories, in all = 5,238 calories per cubic meter of the gas mixture;

For hydrogen and oxygen:

$4 + 1 = 5$ cubic meters $(4 \times 3{,}091) = 12{,}364$ calories in all = 2,473 calories per cubic meter of gas mixture; i. e., only about half of the results in the first case.

A further great advantage of the acetylene-oxygen flame is, that the heat is concentrated in a small primary flame, while in the hydrogen-oxygen flame it is more diffused. The heat of the acetylene-oxygen flame is therefore very rapidly given out to the surface to be welded, while the hydrogen and oxygen flame, by reason of its greater size, loses considerably by conduction and radiation.

The consumption is as follows:

Four volumes of hydrogen, against only 0.59 of acetylene; that is, there is used seven times as much hydrogen as acetylene. But the losses by the oxygen-hydrogen flame are still greater; so that about 1.5 times as much oxygen is necessary as with the acetylene flame. This again increases the hydrogen consumption, so that for the same amount of work about 1.5 times as much oxygen and 10 times as many volumes of hydrogen are required, as where acetylene is used.

As the compressed hydrogen costs for freight and other expenses about 1.25 mark per cubic meter, and the acetylene, inclusive of depreciation, only about 1 mark, the saving by the employment of acetylene is very evident. In practice, hydrogen costs from 2 to 10 times as much.

A complete plant for welding consists of:

(1) An acetylene generator.

(2) A cylinder of compressed oxygen, with reducing valve.

(3) A water seal.

(4) A number of welding burners of different sizes.

(1) The acetylene generator must produce clean gas, free from air. Especially to be avoided as impurities are phosphureted and sulphureted hydrogen, as these make the iron "short."

(2) The oxygen cylinder with its reducing-valve is exactly the same as for the oxygen-hydrogen process.

(3) The water seal is to prevent oxygen getting into the acetylene apparatus in case of any stoppage, as this would form an explosive mixture. The water seal permits the passage of gas in only one direction.

(4) The welding burners are made like an injector; that is, the oxygen coming under pressure exhausts the acetylene under a pressure of about 100 millimeters, equaling say 4 inches of water column. The burners are of various sizes, according to what is required of them.

As regards the cost of the process, it has been shown that with acetylene it is much cheaper than with hydrogen. It is also possible to weld plates of an inch thick with acetylene, which is not possible with hydrogen.

The cost per welded seam is about as follows:

Thickness of sheet.	Oxygen	Acetylene.	Wages.	Total.	
mm.	pf.	pf.	pf.	pf.	cts.
0.5	11	2.5	2.5	5	1.19
1	14	4	3	7	1.67
2	40	10	6	16	3.81
3	82	22	8	30	7.14
4	120	35	12	47	11.19
5	140	37	15	52	12.38
6	210	62	18	80	19.00
8	400	115	25	140	33.30
10	475	140	30	170	40.50
12	800	250	40	290	69.00

The cost per seam depends naturally somewhat on the ability of the workmen. The acetylene process of welding is, however, easily learned, and the workman soon is enabled to make seams that are as strong as the solid metal. In any case, such a seam is better than a riveted or brazed one.

As regards the heat of the flame, there is hardly any material than can withstand it. Brick, pumice-stone, the so-called fireproof brick, even carbide, which is made at a temperature of 3,000 deg. C. (5,432 deg. F.) is melted in a moment; graphite is the only thing that will stand up under it.

The process can be used not only for welding, but also for projecting apparatus, with the light. There is a greater degree of illumination produced than by any other process except the electric light.

In France there were, at the time this paper was prepared, over 800 firms employing this process.

Among the various applications of the process may be mentioned:

(*a.*) Welding iron or copper up to an inch thick.

(1) Replacing riveting for thin sheets.

(2.) Replacing soldering and brazing.

(3) Making boilers and reservoirs, and repairing such, up to an inch plate-thickness.

(4) Welding together angle-iron and profile iron.

(5) Manufacture of tubes in all dimensions, making both lengthwise and end joints.

(*b.*) Welding flanges, pipe, nozzles, etc., whether the material be iron, copper, brass or what not.

(*c.*) Making steel castings, malleable iron, bronze or brass castings.

(*d.*) Repairing fractures in cast iron retorts, faults in general, and in automobile and bicycle manufacture; doing away with all rivets, bolts, screws, and making the frames in one piece.

(*e.*) General industry—all sorts of repairs, making endless pipe-lines, etc.

(*f.*) In mechanical and electric construction works, where several pieces are to be united, even where they are of different metals; as for instance in dynamo armatures, and in making joints in conductors.

(*g.*) In ornamental forging, the manufacture of burglar-proof safes, and the manufacture of sheet-iron ware, either enameled or not.

(*h.*) Welding band-saw blades.

(*i.*) Manufacture of articles for the army.

(*j.*) Making cannon, side-arms, etc.

(*k.*) Mending shovels or spades, hoes, forks, etc.

(*l.*) Repairing gear-wheels of steel, brass, or cast iron.

(*m.*) In locomotive building and narrow-gage railway building, and in shipyards.

(*n.*) Construction of iron ships and motor boats, and repairing boilers on board.

(*o.*) Manufacture of iron vessels.

(*p.*) Manufacture of steel heaters.

(*q.*) Manufacture of iron window-frames.

Also, in any machine shop or establishment where machinery is used, broken parts may be repaired in place.

If the question be asked: "Which of the three processes is to be preferred?" the answer is: "It depends on the conditions."

The first process, with compressed gas, bought in cylinders, is expensive, but requires no special plant; so it is best where there is not often welding to be done.

The second is cheap to employ, especially where the plant is large and there is considerable work, else the depreciation would cost too much, per weld made.

The oxygen-acetylene process is, however, still cheaper to work, and the cost for plant is comparatively low. It is advantageous even for very small transportable plants, as there may be used an acetylene apparatus not larger than a hydrogen cylinder. For large and very large establishments it is possible, and also advantageous, to make the oxygen in the establishment itself, which brings the price down to one-tenth of that where it must be bought.

The lecturer then welded together with very small burners, sheets varying from 0.5 to 3 millimeters (0.02 to 0.12 inch), and also flat iron of 5 to 10 millimeters (0.2 to 0.4 inch) in thickness. In about two minutes he welded a bottom 6 millimeters (0.24 inch) thick, in a piece of iron pipe 60 millimeters (2.4 inches) diameter; the bottom having been chamfered with a file.

A NEW ANALYSIS OF BREAD AND WHEAT

THE coloration of bread and the different substances contained in the wheat grain form the subject of a paper read by Messrs. Bertrand and Muttermilch before the Academie des Sciences. Inasmuch as brown or Graham bread is prepared with flour containing bran, and white bread with pure flour, it is thought that the appearance of the former is due to a solution of the coloring matter contained in the outer shell of the grain. Experiments made by Mége-Mouriés showed that this was not true, seeing that the gray color is caused by the action of a substance on the order of a ferment, during the bread making. This substance, which he calls *cerealine*, is contained in a layer of special cells and these cells adhere to the bran and form part of it. According to him, the cerealine turns starch into sugar and transforms the resulting glucose product into lactic acid, then into butyric acid. It gives "bran-milk" the property of souring and coloring in air. It also alters gluten, giving ammonia, a brown coloring matter and a nitrogenous substance. These experiments made in 1857 were certainly carried out in the presence of various kinds of microbes, and we are in doubt whether the brown color is due to a special ferment or to microbes developed in the bran. After the discovery of oxydases, Boutroux took up the matter in 1895, and claimed that the bran contains laccase and an undetermined substance on which the soluble ferment reacts. The authors find some new facts. The oxidizing diastase of bran is not laccase, but a substance of the type of tyrosinase. Bran and a small amount of water is placed in a filled and corked flask. After some hours, the mixture is pressed and the liquid cleared in a centrifugal machine. To the clear solution is added three times its volume of 95 per cent alcohol, and the resulting precipitate, after treating, is dried *in vacuo*. This precipitate does not contain laccase, according to tests, but contains tyrosinase, as the author shows. This substance is not the only one to be found in the principle extracted from bran. Among the others are the leptomine of Raciborsky, also called *peroxydase*.

REJUVENATION OF WORN-OUT FILES.

THE latest application of the air and steam blast is in the rejuvenation of worn-out files. A piece of portable apparatus has been recently introduced as part of the equipment of the workshop by which ninety per cent of the discarded files of the shop may be reclaimed at a trifling cost. Furthermore, the file is capable of being sharpened in this manner from four to six times. The device is a comparatively small one, somewhat like a forge in appearance, and having a hood. Under the latter is a rack for holding the file which is to be operated upon. The jet, which may be air or steam, or a combination of both, is laden with some abrasive and it strikes the file at an angle of from fifteen to thirty degrees. In this manner the blast acts upon the back or sloping edge of the teeth. The abrasive material falls into a pocket containing water and is drawn from this receptacle and used over and over again until it becomes broken up into such fine particles that it floats off in the overflow of water. The cost of this renewal is said to be one-tenth that of a new tool. Hack-saw blades may be successfully treated in the same manner.

THE SAINT-MICHEL STATION OF THE PARIS METROPOLITAN.

BUILDING A TUBE UNDER THE SEINE.

HAVING to respond to a necessity of the first order, that of diminishing the extent of a traffic that has become dangerous at certain particularly frequented points of the public highway, the essential character prescribed for the Paris Metropolitan Railway is that it shall be subterranean. Exceptionally, in order to satisfy the principle admitted in public works that valleys must be crossed by viaducts, and also to prevent too pronounced oscillations in the lengthwise profile, the viaduct is employed at points at which, making use of wide counter-alleys in quarters that are inactive and distant from the center, the interference with traffic due thereto is, so to speak, of no account. But, on the contrary, and in order to prevent congestion, the use of surface work or work in open cuttings is absolutely banished from the system, their presence being limited to a few works indispensable for connecting the subway with the viaduct and *vice versa*.

FIG. 1.—THE GREAT CENTRAL CAISSON OF THE PLACE SAINT-MICHEL STATION.

The object that the builders of the Metropolitan have in view is to succeed in carrying travelers cheaply and quickly from one point of the capital to another. But as the realization of such a project necessarily involved the creation of communications between the left and right bank of the Seine, it was, as may be seen, to meet in this river the principal difficulty to be conquered. In the system now conceded, the Seine is crossed six times, to wit: at Bercy by line No. 6, which has become the prolongation of the circular southern line; at Austerlitz by line No. 5; at City Island by line No. 4; at La Concorde by line No. 8; at Passy by the southern circular line No. 2; and, finally, at Auteuil by line No. 8 for the second time, without counting the crossing, at La Concorde, of the North-South line, conceded to engineer Berlier. Now, in order to effect these passages, two methods are offered, to wit: The bridge, known from ancient times, and the subway, the use of which under such circumstances dates back to 1825. It is evident that whenever it is not inconvenient to establish viaduct lines it is of interest to make use of the bridge by reason of the greater economy that it presents over every other process, but that wherever an invasion of the street would be disastrous from the standpoint of the annoyance caused thereby as well as from that of esthetics, hesitation is no longer permissible, and the subway must be utilized. Thus what is possible at Bercy, Austerlitz, and Passy, where bridges have been widened or constructed, becomes totally impossible at Chatelet, for instance, where, in order to form the passage, now in process of construction, of line No. 4 (from the gate of Clignancourt to the gate of Orleans) under the Seine and City Island, the special arrangements which we have already described have had to be made.

Among such works there is one that has been particularly remarked. In the first place, the digging up of Place Saint-Michel and Place Saint-André-des-Arts, of which hardly anything but the sidewalks remains, has stirred up sensitive or artistic minds, and then the construction in a 20-foot excavation of huge steel skeletons, which rise to a height of a third story, has attracted the attention of the public, which, generally in a pretty bad humor when its habits are interfered with or when what is doing behind the fence is concealed from it, here endures this test with the greatest patience on account of the interest that it finds in the cyclopean work, which astonishes and amazes it. We purpose, therefore, to satisfy its curiosity by furnishing it with the elements capable of throwing light upon its investigation and putting it in a way of following the work intelligently.

In order to pass under the Seine and City Island, there had to be substituted for the ordinary masonry facing of the current type of subway, for a distance of 3,582 feet between Place du Chatelet and Boulevard Saint-Germain, a metallic facing formed of cast iron voussoirs assembled by bolts. In the sub-fluvial parts corresponding to the passage under the small and large arm of the river, the tunnel thus constituted is further incased by sections 132 and 66 feet in length, in metallic caissons of semi-cylindrical form constructed upon the shore, and then transported to the definite site, ballasted, and sunk vertically until they reach a level such that the distance between the rails and mean level of the water is 36.5 feet. For traversing the land not situated under the Seine, but likewise covered by water, a horizontal tunnel will be constructed by means of a shield and compressed air. Recourse will be had, in addition, to a very curious process of execution for the passage under the Orleans railway at Place Saint-Michel, that of a preliminary congelation of the ground in order to permit of constructing the metropolitan line without any danger of the subsidence of the work overhead. Some persons are astonished that the shield has not been used for the entire length of the direction line, such a process being in their opinion much more expeditious and much less costly, a fact which is true; but it is well to remark that aside from the indestructibility of the blocks submerged under the two arms of the Seine it has been possible, by the use of caissons, very sensibly to raise the profile of the line to such an extent that the highest part of the work comes within about 20 or 24 inches of the level of the river bed, and thus dispenses with the use of very pronounced gradients. Such a result evidently could not be obtained with a shield.

The crossing of the Seine comprised, in addition, the establishment of two stations, one of them at the Flower Market, and the other at Place Saint-Michel. Being destined to rest upon water-soaked ground, these could not be constituted or constructed like ordinary stations. By reason of their too great dimensions, the possibility of using a shield under such circumstances could not be thought of, and so recourse was had to the use of caissons sunk vertically. We think it needless to dwell upon the operation of this now very frequently employed device, supposing our readers to be well acquainted with it. Let us simply recall the fact that the caisson has the appearance of a coverless box, which in most cases is metallic and with perfectly tight walls, entirely enveloping the work to be constructed, mounted upon the shore when it is to be sunk in a river, and upon the place of sinking when it has to traverse only wet ground, and provided at its base with a working chamber to permit the laborers to prepare the way for the caisson and its contents which they have to let down to a definite level, and which sinks progressively by its own weight in measure as the spoil is removed. To prevent the entrance of water into the working chamber, air is compressed into it under a pressure that increases with the depth. The upper and the working chambers are therefore separated by a very strong horizontal partition rendered absolutely impermeable to the air by the application of a thick layer of concrete. The passage of the men and materials from the open to the compressed air, and inversely, is effected through vertical shafts extending to the working chamber, traversing the upper work to so much the greater height in proportion as the travel of the caisson is to be longer, and ending in an air lock. What characterizes the caissons employed for the crossing of the two arms of the Seine by line No. 4, and the establishment of the "City" and "Saint-Michel" stations is that they are intimately connected with the work that they embrace and have to be sunk gradually and then disappear completely with it under the water or under the spoil with which they will be covered, the shafts that establish a contact between the front of attack and the exterior alone emerging.

Each of the stations under consideration, both curved (the "City" of 1,970 feet radius, and the "Saint-Michel" of 984 feet), is composed of three caissons (Fig. 4) forming a unit 387 feet in length and arranged as follows: In the center, a caisson 223 feet in length containing the station properly so called, and, at each extremity, an elliptical well connecting the station with the subway, of a height equal to the distance existing between a point situated at 8 feet below the lower part of the station and the level of the street and designed to contain, in addition to a ticket office, a means of access (stairs and elevators) to the passenger platforms. The work at Place Saint-Michel is therefore being done in connection with the construction of the station of that name. The elliptical caisson on the Seine side and the large central caisson are ready to be sunk, without the aid of compressed air, as long as no water is met with. The mounting of the elliptical caisson, which is to complete the station, will not be begun until after the sinking of the first, in order that too great an encumberment may be avoided.

The large central caisson, constructed by Messrs. Baudet, Donon & Co., which is of semi-cylindrical form, is 541 feet in height and 54 in total width. Its metallic frame is formed of transverse trusses in the form of an arc of a circle placed 4 feet apart and con-

nected by cross ties upon which are assembled jointed iron plates that constitute the external envelope of the work. The station, properly so called, has, in transverse section, the form of a semi-circular vault of 41 feet opening, connected with an elliptical invert by very short arched buttresses (Fig. 3). Its height in the clear reaches 27.8 feet. It will be provided with two lateral platforms for passengers, with a space of 18½ feet for the running of trains, and consequently of a width of 11½ feet (the platforms of the ordinary stations are 13 feet in width) and a length equal to that of the stations, say 246 feet. Its walls are formed of iron plates 3-10 of an inch in thickness riveted to the external shell and stiffened internally by angle irons provided with holes for the reception of numerous split irons forming a bed for a stratum of concrete to which will be applied, as in the other stations, a continuous facing of white enameled tiles. All around this internal envelope will be poured concrete to a depth of three and a quarter feet at the key and of six and a half at the springings of the vault, entirely imbedding the transverse trusses. Moreover, it will be remarked that the iron plates of the external shell, instead of following the round contours of the caisson (Fig. 1) are straightened up vertically at its sides and are maintained by steel stanchions that will serve as webs between two parallel sustaining walls of concrete. The object of such an arrangement is to prevent during the sinking, any movement of the ground which might involve the settling of the structures of Boulevard Saint-André-des-Arts bordering the works.

The working chamber of this central caisson of six feet in height is separated in the direction of its length by a central partition that divides it into two distinct chambers, each provided with four working shafts. The descent of this caisson of excessive dimensions, which, by reason of the inequality of the ground, is liable to get out of plumb, lose its verticality or even to become displaced (weighing at least 18,000 tons, of which 11,000 are steel, and 7,000 concrete) will thus be rendered more regular. After sinking, and the caisson has reached its definite level, a distance of 50 feet, corresponding to about 96 steps or stairs, will separate the platforms of the Saint-Michel station from the ground of the latter.

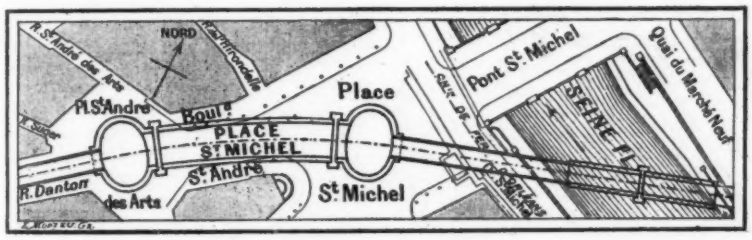


FIG 4.—PLAN OF THE SAINT-MICHEL STATION.

The two end caissons, the structure of which is exactly identical, have an elliptical internal section of which the major axis measures 85 feet and the minor one 60.5. The Saint-Michel caisson, now being sunk (Fig. 2) is to rest at about 75 feet beneath the Place. For 65.5 feet of its height, its tight walls consist of a double lining of steel of a weight of 650 tons, having an interval of 5 feet provided with counterforts and crossbraces and filled in with 2,500 tons of concrete. Once in place, the continuous ring thus formed will be surmounted by a masonry coping 6½ feet in height which will support a very strong metallic floor, completely closing the work and upon which the roadway will be re-established. With the exception of a slight difference in height, the elliptical caisson of Place Saint-André-des-Arts is exactly the same. It is well to add, however, that the caisson on the Seine side is so arranged as to render possible the entrance of the Sceaux-Limours line in case its eventual extension to Quai d'Orsay should be decided on. These caissons, as we have said, are both to serve as a junction between the station and the subway, and are therefore provided, facing the station, with a feeder of the same section as the latter, and, facing the subway, with a short channel, where, on the Seine side, will be finished the putting in place of the metallic facing and, on the Boulevard Saint-Germain side, the travel of the shield will terminate. In order to prevent the entrance of water into the interior of the elliptical caissons and the central caisson during the sinking, the sections reserved for the passage of the line are closed by tight and dismountable bulkheads, of metal for the first and of wood for the second, and which, after the sinking of the caissons, will be dismounted in order to assure the continuity of the tunnel. The end wells and central caisson are, in fact, separated by an interval of 5 feet purposely reserved for obviating the irregularities that might be produced during the sinking and to prevent any chance of shock or accident, and which constitutes a joint for the forming of which a very ingenious process will be employed. From one elliptical caisson to the other the station thus measures exactly the 246 feet that it is to be. The riveting of all of this metallic part has been done with the well-known American Ingersoll hammer-riveting machines, which, from the viewpoint of rapidity of execution and quality of work, have given the best of results.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

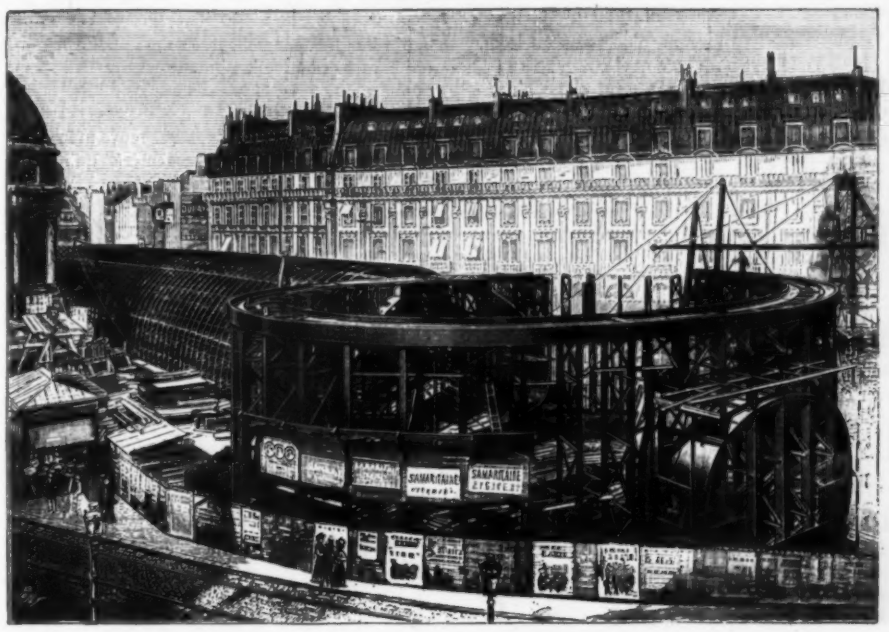


FIG. 2.—THE END ELLIPTICAL CAISSON NOW BEING SUNK AT PLACE SAINT-MICHEL.

PREPARATION OF A MOTH-EXTERMINATING POWDER.

THE following recipe for preparing a moth-exterminating powder called "Antimothine" is given by the Pharmazeutische Zeitung of Berlin: 500 parts by weight of finely-sifted sawdust are thoroughly mixed with 5 parts of powdered ammonium carbonate, prepared with oil of lavender. To this 10 parts of glacial acetic acid, mixed with 10 parts of water, are added and mixed until the effervescence, caused by the acetic acid, has ceased. By this treatment, the sawdust is made ready for the admixture of further ingredients. A second mixture is then prepared as follows: 500 parts by weight of finely-sifted sawdust are mixed with 20 parts of glacial acetic acid, diluted with 20 parts of water, 15 parts of spirits of wine, in which 5 parts of camphor have been dissolved, and 10 parts of American turpentine oil. This second mixture is then added to the first, and 40 parts by weight of ammonium carbonate prepared with oil of lavender added to the whole. The mass is left to dry in a well-closed receiver.

When required for use, the powder is scattered in rooms or receptacles containing the articles which are to be protected from moths, the articles being either suspended over it or laid in it. The powder may, however, be strewn over the objects in the usual manner, without the latter suffering any injury. Owing to the fact that the active constituents are contained in the vehicle (cellulose) in a finely-divided state, their action is certain and lasting; moreover, an agreeable smell, injurious to moths, is developed by the ammonium carbonate prepared with the oil of lavender.

Other suitable substances capable of absorbing the active constituents, such as infusorial earth, sponge, etc., may be used instead of sawdust, as they are more or less substitutes for cellulose.—Neueste Erfindungen und Erfahrungen.

FIG. 3.—VIEW TAKEN FROM THE INTERIOR OF THE CENTRAL CAISSON.

Concrete abutments of structures in salt water built for the Massachusetts Highway Commission showed some disintegration in earlier masses of masonry, and for this reason on all such work at the present time a mortar of one part of cement and one part of sand has been used on the face to the depth of about 1½ inches. According to the Engineering Record, this is placed by using a thin metal diaphragm separating the richer front mortar from the standard concrete, and withdrawing the diaphragm when the concrete is in place and before it has set appreciably.

THE ART OF GALVANIZING.—II.*

BY ALFRED SANG.

THE NATURE OF ZINC DUST.

THE vapor of zinc, which is given off at a temperature of 1,000 deg. C. or more, at the inception of distillation, comes into contact with the comparatively cold atmosphere of the flue, and the sudden chill causes a rapid condensation of the vapor, so rapid indeed that it skips the liquid stage and drops in the shape of perfectly spherical particles, of which about 30,000 million can be crowded into a cube measuring one-sixteenth of an inch in every direction. This impalpable powder which, notwithstanding its high specific gravity—for it is only about 10 per cent lighter than zinc—can be blown about like lycopodium, is used mostly by paint manufacturers, and is sold packed in barrels holding about 1,500 pounds. It is 10 or 15 per cent cheaper than virgin spelter at equal content of free zinc. It cannot be melted into slabs on account of its rapid oxidation at a very low temperature.

The peculiar properties of zinc dust have been ascribed by some to the presence of cadmium, which being a more volatile metal is distilled first from the ore and condensed in the flues. One observer found quantities ranging from 0.283 to 0.794 per cent in flue dust after two hours of furnace operation. Others have claimed that these properties are due to the presence of zinc oxide or other impurities. No plausible reason for these theories has as yet been advanced.

Most of the zinc dust is produced in Belgium or in Silesia, and a sample which I have had analyzed showed the following composition:

	Per cent
Metallic zinc	88.95
Zinc oxide	6.88
Lead	3.45
Cadmium	0.62
Sulphur	0.055
Iron	0.04

G. Williams, an English chemist, has shown† that zinc dust takes up water and decomposes it, and gives up its hydrogen on heating. He has also shown that it absorbs hydrogen at ordinary temperatures when surrounded by it in a moist condition, and that heated alone it yields 50 times its volume of hydrogen, but when heated to redness with an equal weight of zinc hydro-oxide it gives off 535 times its volume of hydrogen. All this may have some bearing on the antics of zinc dust and on Sherardizing, but, as I am about to show, it is unlikely and lacks confirmation, both theoretical and practical.

IMPURITIES ARE A NEGLIGIBLE FACTOR.

It is my belief that these impurities have little or nothing to do with the properties of zinc dust, and that the reasons should be sought for in its mode of production.

If under similar conditions of rapid cooling we produce other solid bodies we get unstable and brittle results. If a bead of fused glass is dropped into water a "Rupert's tear" is the result. As you know, a Rupert's tear is very unstable, and, whereas for a drop of normal glass of similar dimensions several good strokes of the hammer would be required to pulverize it, the Rupert's drop can be shivered to fragments by breaking off its tail with two fingers or by scratching the surface film, whose tension keeps the drop together. The difference of energy required to effect the destruction of the normal drop and the Rupert's drop is enormous.

If we assume that zinc dust is in this critical state we can explain almost every one of the effects which have puzzled chemists during the past forty years. Douglas Carnegie‡ found that zinc dust *instantly* reduced ferric to ferrous salt, *and this even in neutral solutions.* (The italics are his.) This action, he states, was considerably quicker than with granulated zinc in the presence of sulphuric acid. He was at first inclined to ascribe this wonderful efficiency to the occluded hydrogen mentioned by Williams, but further experiments, which I need not detail, showed that he was mistaken. Referring to another chemical operation in which zinc dust acted with equal promptness, he writes: "Zinc dust merely effects instantaneously the dechlorination which I found zinc foil required several hours to effect."

ITS AFFINITY FOR OXYGEN.

It is so well known that zinc dust has a great affinity for oxygen at a low temperature that it has been used for a long time in the discharge style of printing of cotton goods. The fabric is first dyed a plain color and it is then printed on with a discharge paste. The zinc dust acts as a reducing agent at the temperature of the boiling water in which the cloth is dipped to effect the discharge.

A fact that is undoubtedly responsible in a great measure for the mystery attaching to the action of zinc dust is its readiness to oxidize. It is only when oxidation is put out of its power, as in the closed Sherardizing drum, that heat will produce sufficient overstrain to cause the particles to burst into vapor. This vapor so suddenly released will condense instantly on the coolest spaces it can find. In dry galvanizing the coolest spaces are on the articles in the drum, and the drum itself being always hotter does not receive any deposit. One drum has already lasted two years without being coated.

Zinc dust appears to break down into vapor at about 150 to 200 deg. C., although it undoubtedly begins to disintegrate at a lower heat. As the pressure increases it takes a greater amount of heat to cause the breakdown. As the vapor condenses the pressure is relieved and the hotter particles of dust are vaporized and reestablish an equilibrium.

In reference to this question of the vaporization of zinc, it is a well-known fact that zinc will at ordinary temperatures affect a photographic plate. This has always been ascribed to zinc vapor, which exhibits in that state great chemical activity. Radiology, the new science, is expected to bear the burden of all such actions, and I suppose I ought to say that the action of zinc on photographic plates is due to the slow disintegration of its atoms into energy and helium.

In a small way it is a significant fact that zinc dust is intensely exothermic in its reactions, which means that these reactions are accompanied by the production of heat. I could also mention the property first pointed out by Schwarz, which zinc dust has of combining violently with sulphur by percussion.

It has been known for some time that a cement made out of certain oils and zinc dust possesses the useful property of becoming exceedingly firm and adhering closely to iron, steel and other metals, when heated to a temperature of 150 deg. C., or even less, if treated for a sufficient length of time. The theory of the nature of zinc dust which I have given explains this hardening by the release of the zinc from its peculiar condition to form a solid without the formality of passing through the liquid stage. In the body of the cement it is protected from oxidation and the zinc becomes mechanically continuous. It is an excellent composition for calking cracks and crevices in metallic objects, for packing joints and for smoothing off the surface of castings.*

I think that I have given a sufficient number of examples to show that zinc dust is a substance in a very abnormal physical condition, and if I have spent so much time in doing so it is because I feel certain that by taking advantage of this abnormal condition the metallurgical industries will before long reap important benefits.

ZINC VAPOR AND FERROZINC.

I must tell you more about zinc vapor. This vapor is a gas just like air or any other gas and subject to the same physical laws, but as it is produced by the breakdown of zinc dust particles at a very moderate temperature it finds itself in the gaseous state at a point below its critical temperature, and it will therefore readily assume the solid state by condensation under its own pressure, confined as it is within a retort.

When iron is pickled, hydrogen is given off on the surface and rises to the top of the vat. The pickle works its way into the metal and hydrogen is given off below the surface and remains occluded. This occlusion has very surprising results; the surface of the iron is hardened, and if it is to be drawn through a die or worked in any way, it is necessary to bake out the gas. Hydrogen has been long suspected of metallic proclivities; it is often classed as a metal. It is known to form an alloy with palladium, and it is supposed to alloy itself to the iron to produce the hard skin of which I have spoken. Zinc vapor acts in the same way in dry galvanizing, but it forms an alloy all the more readily because in its normal condition it is itself a metal as we generally understand that rather arbitrary term.

ZINC VAPOR FORCES ITSELF INTO THE PORES OF METAL.

Being a gas, the zinc vapor can force itself into the pores of the metal and form a deposit to a depth which will increase with the duration of the treatment. A small piece can be alloyed throughout. An alloy of zinc and iron produced by fusion would be a sorry article when it came to be tested. "Zinceisen," as it is called, is zinc ruined by the addition of a quantity of iron which renders it brittle and worthless. By alloying with vapor at a low temperature the qualities of the metal cannot be injured, but they may be greatly improved by the zinc forming an intermolecular binding, which fills spaces which would otherwise allow motions of the particles under stress which might injure their cohesion. The vapor deposit should increase toughness, and it is quite possible that this theory may have some bearing upon the general subject of the nature of alloys.

By using carbon as a condenser for free zinc vapor, out of contact with the dust, I have obtained a perfect zinc dew. I used a common arc lamp carbon, and the drops on the top were large and reduced in size down to microscopical proportions on the edges. Here and there on the inside were traces of zinc, showing that the gas had penetrated the mass. The zinc vapor had not alloyed to the carbon, the specific heats being wide apart, whereas I have observed that the closer are the specific heats of the zinc and the material to be coated at their working temperatures, the more quickly and firmly would they combine. It is no doubt on this account that copper becomes coated so much more rapidly than does iron.

Improvements in dry galvanizing will undoubtedly be founded on the intelligent control of the temperature, but to this end temperature readings will have to be taken inside the retort and not in the furnace, as heretofore.

RESULTS OBTAINED BY WORKING WITH GAS ALONE.

Working with gas alone, and under the special conditions necessitated by the peculiar circumstances of the experiments, I was able to obtain quite a variety of deposits.* Rapid cooling will cause the zinc to condense as crystals, the adherence of which to the iron is, however, inversely proportional to their size. Normal cooling would seem to yield in all cases a fine glossy surface of what can be appropriately termed ferrozinc.

Examining this ferrozinc under about 400 diameters of enlargement, it exhibits the structure of the original metal. A piece of mild steel which had been thoroughly pickled and which had been treated by vapor only, and was, therefore, free from any exterior zinc coating, such as would have concealed the alloy if operated on in contact with the dust, exhibited the usual structure of an etched mild steel. This ferrozinc appears to be harder than the original iron and its rust-proof qualities are the true secret of the exceptional efficiency of Sherardizing.

THE ONLY WAY TO TEST DRY GALVANIZING.

The Preece test with sulphate of copper is not a fair test for dry galvanizing. It is almost without significance for the following reasons: The outer coating of the slightly oxidized zinc particles resists the test better than does the brighter hot coating or the porous electrolytic one, but the alloy, obtained by vapor treatment alone and which is present in all dry galvanizing, readily takes the copper just as the iron itself would, and yet it will resist corrosion perfectly. The copper will deposit without destroying the zinc and the test is, therefore, worthless. The only way to test dry galvanized work is to put it into service.

The alloy known as nickel steel does not rust easily, and yet in a nickel plated article if the nickeling is partly removed the iron will be corroded. This shows that we must not expect contact theories to adapt themselves to perfection to metals in solution, to alloys. The alloy of nickel and iron resists corrosion, and in my opinion it is a parallel case to that of ferrozinc.

The Romans, to make their brass, which they called "orichalcum," threw cadmia (oxide of zinc) on highly-heated copper. The more recent calamine brass process, which was in use until about one hundred years ago, consisted in heating calamine (zinc silicate), granulated copper and coke dust in crucibles, the fusion and alloying taking place at a temperature considerably lower than the melting point of copper. I thought these two points of history might interest you by comparison and as aids to the digestion of the most recent developments.

THE THEORY OF DRY GALVANIZING.

Let us enter the dry galvanizing retort and endeavor to find out what takes place. Which guess will offer the most plausible explanation? It is an established fact that in Sherardizing the presence of zinc oxide is necessary. We might suppose, therefore, that a molecule of oxide is reduced by voltaic action when it comes into contact with the iron. The zinc attaches itself to the iron, which acts, therefore, as a cathode in electrolysis, and the oxygen travels in the opposite direction, combines with a free molecule of zinc to form a molecule of oxide, and goes through the same performance as before. I have excellent reasons, which I must keep for later publication, for believing that this hypothesis is pretty close to the truth, if not the true explanation of the action in dry galvanizing.

The outer coating is composed of reduced zinc in granular form, and the silver gray appearance may be

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*Continued from SUPPLEMENT No. 1645, page 23. Read before the American Foundrymen's Association, Philadelphia.

† Chemical News, vol. iii.

‡ Transactions Chemical Society, London, year 1886, p. 468.

* This composition is patented.

* Patents applied for in all countries.

due to slight oxidation of the surface. Whatever the true explanation may be it is of little immediate interest to practical men, but it is of great interest to scientists, who are expected to continue furnishing their abstract facts to serve as souls to the concrete bodies created by inventors. The inventors, while claiming all the credit, usually sell or lose most of it to men who put these inventions into practical use. He laughs best who laughs last, and by the time the invention has become an industry the poor scientist has been entirely forgotten, except to be occasionally dubbed a theorist, a dreamer, a simple soul, mild and childlike—for of such is the kingdom of Heaven.

THE EFFICIENCY OF DRY GALVANIZING.

The efficiency of dry galvanizing, which has been proved by thorough testing, both in England and Germany, is due to its fulfilling the conditions which I have set forth in the early part of this paper. Considered merely as a covering it fits as closely as does an electrically deposited coating, and it is impenetrable because free from pores or cracks. As a mechanical protection, it resists both abrasion and impact better than hot or cold work, because of the qualities of the ferrozinc alloy. Zinc itself is superior to both tin and lead in ductility and tenacity.

Considered in relation to contact effects, the zinc distilled as vapor and alloyed to the iron is absolutely pure, and the span between it and the iron in the electromotive series is, therefore, extended, as compared with a zinc containing a percentage of impurities. Its contact with the iron in the body of the alloy is as perfect as is possible. In relation to corroding agents, its granular structure offers a maximum surface for them to decompose and, therefore, increases the ratio in which the coating acts by its own decomposition as a protection to the iron.

COMMERCIAL SCOPE OF DRY GALVANIZING.

It is a noteworthy fact that, while many articles have appeared in technical and scientific journals about Sherardizing, not one word of criticism or denial of its claims has as yet been offered. I have been looking for serious criticism for some time, but when I have found doubters I have only succeeded in making new converts. The process has always appealed to scientific men because they are in position to appreciate the solid scientific foundations of its claims.

The new process has not entered the field as a competitor to galvanizing alone. In a great many instances it can take the place of coppering, of nickel plating and of tinning, where the articles are not to be used for the preparation or handling of foodstuffs. To these I should add the large amount of copper and brass articles, from tubing to typewriter and sewing machine parts, which are now nickel plated. An interesting point in relation to the various methods of protecting metals is the price of the metals themselves. Nickel is seven and three-fourths times, tin and aluminium seven times, copper four and one-eighth times, and antimony three and one-fourth times as high in price as spelter, and at equal efficiency against corrosion the lightest coating is one of zinc as applied by dry galvanizing.

Analyzing the various items which go to make up the cost of dry galvanizing we find that in every instance there is a saving, either over the hot process or over the electric process. In most cases the saving is over both of the older processes.

INITIAL EXPENSE.

A plant for Sherardizing is less expensive than a hot plant and very much less so than an electric plant. Every part of it is of a simple nature, and calls for neither feats of engineering nor the solution of any out-of-the-way problems. It is very much like a plant for close annealing, and whereas the depreciation on a hot plant is usually taken at 50 per cent per annum, the depreciation on a Sherardizing plant would not exceed 10 per cent, which is the depreciation commonly figured on an electrolytic plant. The drums are not made of perishable hard rubber or wood, as are those for electrolytic galvanizing. The process can be carried on in the main manufacturing building and the pickling done in the cheapest kind of an outhouse.

THE SAVING IN COST OF ZINC.

For an equal thickness of coating the zinc actually deposited is about the same in value, whether derived from dust or from spelter slabs. It is less than the anodes used in electrolytic work, which have to be cast specially and are very often of odd or complicated form. Even less zinc is required than in the electric process, because an equal thickness is more effective and because the distribution is fully as even. In Sherardizing there is nothing to throw away, but sufficient dust (from 1 to 5 per cent) is added from time to time to replace that of the weight of the articles coated which has been used. There is no equivalent to the unsatisfactory results due to using spelter recovered from dross and, therefore, contaminated by the presence of iron.

In electro-deposition an unobstructed path is required between the anode and the object for the dissociated ions of the salts in solution to travel. If any part is hidden or recessed no deposit is made, and the parts furthest from the anodes have the lightest coating. In addition to this, it must be understood that the anodes are not entirely used up, and part of them is lost at the bottom of the tank, and as eaten-out remnants they cannot be used to the vanishing point.

It is hardly necessary to point out the enormous saving in the quantity of zinc used, as compared with the hot process. Hot galvanized articles have as a rule a much thicker coating than is necessary, because most of them cannot be conveniently wiped like wire or band iron. In Sherardizing all the zinc is consumed, and the thickness of deposit is regulated just as readily as in the electric process. In the hot process a large percentage of spelter is converted into dross and skimmings, and, while much of it is recovered, the net loss cuts quite a figure on the cost sheet.

THE SAVING IN LABOR.

Sherardizing is like annealing in that it requires but a small amount of labor, and that unskilled labor, placed under proper superintendence. A drum holding one or more tons of articles can be left to itself for half an hour or more, subject to an occasional turn; in the meantime another drum is being prepared for Sherardizing, while the first will be cooling. Suitable partitions will allow of several classes of small articles being Sherardized in one drum without mixing.

Hot galvanizing requires constant attention and handling, which can seldom be done by one man, even with the aid of overhead trolleys and similar fixtures. It is not a mechanical or automatic process, but one of hard manual labor, and the regulation of temperature and methods of dipping require the attention of an experienced galvanizer. As a leading authority on hot work has written: "Considerable skill is required to bring a piece of work out of the metal and cool it so that the surface will be smooth, free from blisters and with no lumps of surplus metal attached."

For the electric process at least one man possessing some knowledge of electricity and of all the whims of electrolytes is needed. In electro-deposition irregular shapes, excepting in the case of very small articles, require regular-shaped anodes, but in Sherardizing the dust, every particle of which may be considered as a minute anode in itself, is used just as it comes from the refiners for any size or shape of article.

By combining the advantages of both the old processes Sherardizing enables a manufacturer to galvanize, with one plant only, articles which have hitherto been divided between the two processes, the small ones being electro-galvanized and the large ones dipped. Less care is needed in cleaning the articles to be Sherardized, and oil or grease, far from being objectionable, is helpful to the process, because the volatile hydrocarbons help to prevent oxidation of the dust. The addition of grease or vaseline has indeed been found to be of some advantage in many cases. Furthermore, the articles can be put into the drums wet, as they come from the washing tank. The labor of recutting threads is eliminated. Bolts, screws, and nuts can be put in the drum just as they are delivered from the machines, covered with oil or cutting compound.

With small installations the process can be worked intermittently. The low cost of the plant warrants a manufacturer in running a drum two or three days a week instead of sending his work out, thereby saving time, freight, and jobbers' profits. The temperature required is low and it takes very little time to start the furnace, and where gas is used this element of time may be almost disregarded. This low temperature also suggests using the waste gases of annealing and other furnaces, and in many cases it will be found economical to place a whole day's production in the retort and leave it in over night, with the night watchman to keep his eye on the pyrometer. There is no labor for skimming and drossing, no pot to scrape at unexpected times, no furnace to destroy and rebuild at all too frequent intervals.

THE SAVING IN POWER AND FUEL.

The plainest fact about hot galvanizing is its thermal inefficiency. The pot must be kept going day and night, whether in use or not, and even during its operation much of the heat is lost by radiation and by having to bring the articles to the temperature of the bath. On the other hand, power is seldom an item of any consequence, whereas in electrolytic work the amount of current consumed is quite large, for a deposit which is meant for something more than exhibition purposes or to be buried out of sight and forgotten. This is seldom appreciated because electricity is unobtrusive in its action. The cost of electro-galvanizing thin sheets is prohibitive on account of the amount of current consumed. In Sherardizing the heat is very low and is kept in by a lining of refractory material; the articles do not have to reach the temperature of the zinc dust, and the apparatus is always ready for work on short notice. The temperature does not have to be varied to suit the different sizes and classes of articles to be coated, and, as I have suggested, waste gases can be used under any circumstances.

OTHER FACTORS OF ECONOMY.

With the new process less acid is used than in the electrolytic process, because the cleaning does not have to be so thorough. The vapor works its way under specks of dirt, and bare spots cannot exist. No flux of any kind is needed, as in hot galvanizing, and there are no comparatively high-priced electrical supplies to be bought.

There is no danger whatever from explosions, no broken casting nor distorted ironwork to replace, and the temper of the finest steel blades and of steel springs is in no way injured by the low temperature used. This may at first seem strange, and will not be perfectly clear until we know something more about the temperatures existing and the reactions taking place in the retort.

VARIOUS APPLICATIONS OF DRY GALVANIZING.

Sherardizing will not fill an uncalked seam and act as a solder. This is its one limitation, but it has a great variety of new applications to make up for it. Fly screening can be galvanized, and the business parts of agricultural implements, such as mower and harrow teeth, can receive adequate protection at a low cost without impairing their qualities.

Flashing a surface electrically to discover flaws has been in use for some years, and dry galvanizing will render the same service; it is, in fact, being used at the present time for this very purpose for boiler tubes. However, while electric flashing is worthless against corrosion, a flashing with zinc dust or vapor is very effective as a rust preventive, and of particular service for articles which are to be shipped across the ocean.

Within reasonable limits innumerable machined articles, tools, locomotive and engine parts can be flashed with zinc and be effectively protected against rust under the conditions of their operation, whereas at present they must be periodically cleaned at the expense of their appearance and of the accuracy of their fit. Articles, such as wire, tubes, etc., either flashed or coated with a heavy deposit, can be drawn out, the coating drawing out with the material itself.

A brilliant and permanent polish, which can hardly be distinguished from nickel plating, but bluer and more like silver, and a better reflector of light, can be given to Sherardized articles by means of the usual burnishing tools and machines, but unlike nickel plating it is absolutely rustproof. This polish is not temporary like that of electro-galvanizing, and it is hard and durable if worked down, as it should be, to the ferrozinc. The reason that it does not whiten by corrosion, as might naturally be expected, is because the surface has flowed to an impervious film and the iron is shielded from any contact effects.

In this connection it should be remembered that highly-polished steel is relatively rustproof. If, however, nickel plating is preferred, a light Sherardizing before plating, instead of coppering, will insure very thorough adherence of the nickel to the ferrozinc, and superior rustproof qualities will be obtained. It has been shown that it is very difficult to volatilize zinc from alloys when there is any nickel present.* Sherardized aluminium can be electroplated and the objectionable soft surface be overcome, not to mention the finish and appearance.

Sherardizing has been found to protect silver from sulphureted hydrogen, which blackens it; it can be applied very lightly before polishing without altering the color. When aluminium has been Sherardized it can be readily soldered. This is expected to do away with the very unsatisfactory riveting of articles made from aluminium sheets. The latest application is for inlaying or damascening, and this art is being carried out in England on a commercial scale. A variety of colors can be obtained by using different dusts and by varying the time, thereby obtaining alloys of different tints. The designs shade off in a pleasing manner beyond the edges of the stopping-off material, which acts as a stencil in setting graphical limits to the action of the dusts and vapors.

It is very seldom that in the history of invention we find an improved process which corrects so many defects, removes so many limitations of the processes in use, and creates so many new and novel applications as does dry galvanizing.

William Findlay Shunk, the engineer under whose supervision the Manhattan Elevated Railroad of New York was constructed, died on June 22 at his home near Harrisburg, Pa. He was born in Harrisburg in 1830, and was the son of Governor Shunk and the grandson of Governor Findlay. Mr. Shunk was graduated from the United States Military Academy, but after a short tour of the sea left the service to become an engineer for the Pennsylvania Railroad. His most notable work was the construction of the New York elevated railways. He also laid out the Chicago elevated, and made surveys for railroads in South and Central America. He was made a State Forestry Commissioner in 1890. He wrote several books.

* See A. R. Haslam in Chemical News, vol. II.

GUN DISTRIBUTION ABOARD MODERN BATTLESHIPS.

ITS INFLUENCE ON NAVAL TACTICS.*

THE means of attack and defense of a battleship are: the gun, the torpedo, and the ram; the last two, of course, are only occasional weapons; a special importance must not be denied to the ship's engines, for only engines of high power can assure an effectual use of the weapons. If the conning tower represents the brains of the ship, the engines may with equal justice be called its heart.

The chief weapon of the battleship was, and still is, the gun, at present the heavy 30.5-centimeter gun—the more of these guns a battleship has, the better.

The leading aim in battleship construction is to obtain the maximum effective fire of the entire battery on the broadside. Tactically this effort may be thus expressed: The enemy will be kept abeam when possible, to obtain the best use of this battery.

Within the broadside arc of train of 90 deg. (eight points), 45 deg. forward and 45 deg. abaft the beam, the maximum number of guns can be brought to bear; this fact influences every tactical maneuver. If either of these extreme bearings be passed during an engagement a part of the battery must cease firing, which is naturally equivalent to lessening one's own fire.

Keeping the enemy abeam is, however, not only the best offensive, but also the best defensive position. The longitudinal and vertical errors of guns are much greater than the lateral errors; a ship with the enemy on the bow offers a target of greater height than on the broadside on account of the conning tower, bridges, and other upper works.

In this position, as the middle of the target presented will generally be aimed at, the longitudinal and vertical dispersion will have a larger area for accidental hits, for shots will hit that would otherwise pass over the ship. The conning tower, in this case, becomes a "catch all." With the broadside turned to the enemy, this height and the depth in range of the target presented is less than with the enemy on the bow; and therefore chance hits due to longitudinal and vertical dispersion will be reduced to a minimum. In broadside fighting, not only can the greatest possible number of guns be brought to bear, but the probability of chance hits is lessened.

[While it is true that under some conditions a ship bows-on offers a better target than when broadside on, it is thought that the author greatly exaggerates the disadvantages of the latter position. The bow presentation offers a higher but narrower target than the broadside presentation, and from that point of view is easier or harder to hit according to the relative values of the vertical and lateral mean errors of the gun, the relation between which errors varies with the range. When firing at a directly approaching ship the lateral errors of gun fire should be small, but, on the other hand, the range is changing most rapidly. Bow-on, the hits are much more likely to be glancing, and moreover a waterline hole near the bow is less important than one on the broadside. The conning tower, forward turret, and fire control station, as a group, are the natural point of aim, and offer the same target whatever the presentation of the ship. This refers to gun-fire only; the broadside offers an enormously better target for torpedoes than the bow.]

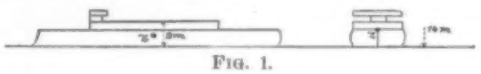


FIG. 1.

FIG. 2.

The same thing holds true for several ships maneuvering in formation. The best battle formation is therefore the simple exact column; mass formations are fundamentally bad, because a compact mass is favorable to wild shooting by the enemy; and, besides,

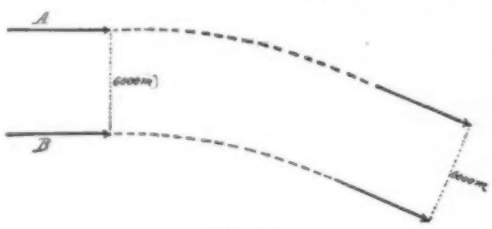


FIG. 5.

it would result in a reduction of one's own fire, on account of the unavoidable masking of the fire of some of one's own ships while executing evolutions.

As victory is not won merely by shooting, but by hitting, it is essential to so maneuver as to avoid frequent changes of target—after the range has once been obtained.

This can most readily be done by taking up a position abreast the enemy, at a favorable range, on a parallel or nearly parallel course.

A restless conduct of a battle, caused by constant turns, or by the execution of maneuvers, which require large changes of course, makes it necessary to find the range anew, after every change; and thus prevents the attainment of what is wanted—a continuous and intense fire.

[Changes of range embarrass both sides equally, but changes of bearing caused by turning are detrimental only to the side turning.]

One's own fleet can always change the range by small changes of course not evident to the enemy, for example, one point at a time. These movements should be made without signals; the leader of the column turns gradually toward or away from the enemy; and the other ships follow in his wake.

As the change of distance is accurately known to the one making it, he can renew the engagement sooner than the enemy; he must merely to avoid "cease firing" carry out changes of course very gradually; the fire control stations, the battery or other gun commands will be informed of the desired changes of range at the proper time by a message "Range is increasing" or, "Range is decreasing." It is therefore evident that if *A* (Fig. 2) is not to drop behind *B* in a broadside fight using broken courses, he must have a slight advantage in speed.

[If B adopted the same tactics, no advantage would result to either side. The real usefulness of the plan of turning very slightly toward an enemy in parallel column lies in its preventing a faster enemy from increasing the range. See "The Fast Wing," United Service Magazine, January, 1907.]

To obtain a certain distance, the side attempting to open distance must turn away from the enemy, and hold him within the after bearing (45 deg. abaft the beam) of the forward turret, in order to keep up the fire from all his guns; to decrease the range, he must turn toward the enemy; but cannot get outside of the extreme forward bearing of the after turret, in order not to lose a large part of the effective fire from his own guns. These limiting bearings of 45 deg. forward and abaft the beam impose the condition that the fundamental position (a course parallel to the enemy) must not be changed more than 45 deg. (4 points) to starboard or to port.

If *A* be faster than *B*, he can always regulate his range after getting it; the slower *B*, no matter how he maneuvers, cannot prevent *A* from carrying out his design. The greater *A's* superiority in speed, the sooner he can carry out his purpose. Even if *B* turns away eight points, *A* will follow, and overtake him.

[But unless the difference of speed is beyond probability, the slower fleet can maintain a constant range by the method just mentioned for a period long enough to produce decisive results.]

It is essential, in carrying out the scheme of evoluting in exact column as a battle formation, that the commander-in-chief shall be at the head of the column; he leads his fleet to and regulates the most favorable range for battle, in the manner already explained. He would not be able to do this from a position near the middle of the column; in this case, he would be just as much under the enemy's fire as at the head of the column, with the additional disadvantage that he could not make his plans known to the head of the column fast enough; and, in case a lucky shot carried away his signal mast, he would lose command during the rest of the action. From a position abreast the column on the side opposite the enemy, he would not be able to control his fleet much better; and, eventually, on account of smoke from his own column, he would lose sight of the enemy. It is absolutely essential in a naval battle, where events follow each other so quickly, and every movement of the enemy must be observed and answered with the greatest accuracy, that the commander-in-chief should be at the head of the battle column.

[There is room for question as to the best position

FIG. 6.

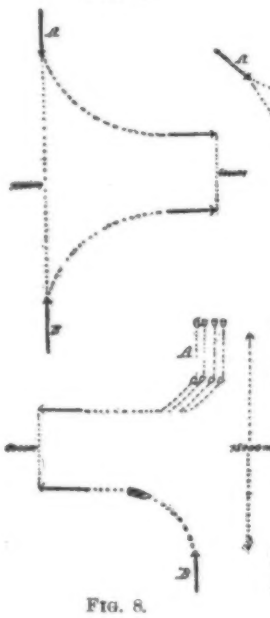


FIG. 7.

FIG. 8.

FIG. 9.

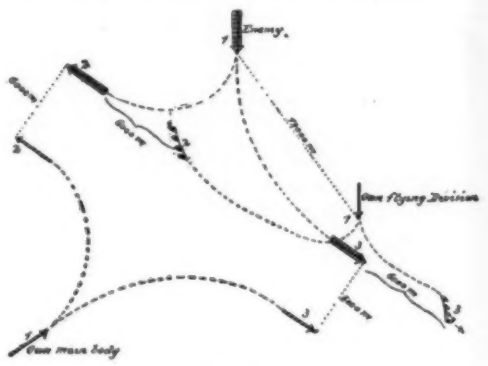


FIG. 11.

FIG. 3.

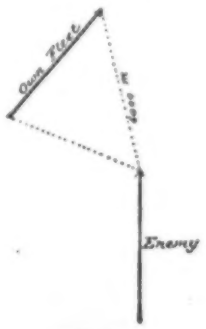


FIG. 4.

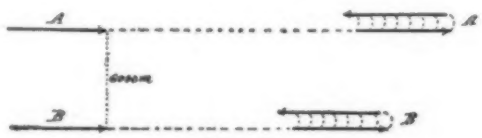


FIG. 10.

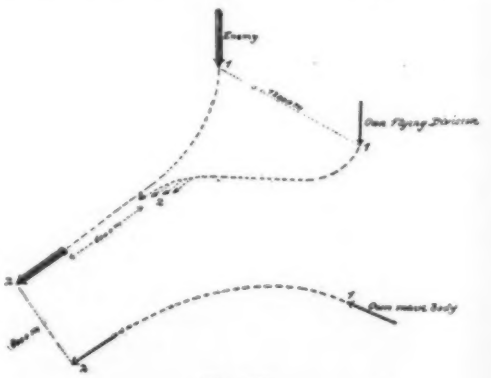


FIG. 12.

* Translated by Lieutenant-Commander H. F. Bryan, U. S. N., from the Mitteilungen aus dem Gebiete des Seewesens. With comments by Prof. P. R. Alger, U. S. N., and Commander B. A. Fiske, U. S. N. From Proceedings of United States Naval Institute.

for the commander-in-chief in action. From the point of view of the preservation of the flagship it would be advantageous to have her lead in the case of the faster fleet and be the sternmost ship in the slower fleet.

The author's objections to having the flagship abreast the column instead of in it do not seem to be of controlling force, as the commander-in-chief could probably see better from a point outside the smoke of the firing ships than if his were one of them; certainly the other ships could see him better. The real question

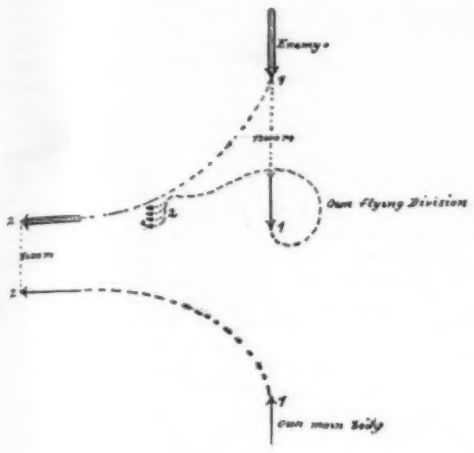


FIG. 13.

seems to be whether or not it is worth while to provide a special ship for this purpose.]

A fundamental principle of battle command is to use one's own fighting strength in its widest possible development; that is, to develop the strongest possible gun-fire while permitting the enemy to keep up the fire from only a small number of guns. To obtain this, an effort must be made to rake the enemy's column; for this, the T position is best suited.

From the T position, or one approximating to it, Fig. 4, the entire fleet can keep up a concentrated and continuous fire on the enemy's leading ship.

If the fundamental position (both lines parallel to each other) be not maintained, and the faster *A* wants to get ahead of and rake the slower *B*, *B* simply turns away; this results in both sides turning in concentric circles, the circumferences and radii of which are proportional. *A*, notwithstanding his superior speed, can never reach the T position. If *A* be only slightly superior in speed, the radii of both concentric circles are very large and only differ slightly from each other.

[*This argument does not take account of the possible, or even probable, proximity of land, which might prevent the slower fleet from turning away.*]

If *A*, however, be 6 knots faster than *B*, the radii will be smaller, and *A* can force *B* to make a loop. Such a marked difference in speed between modern fleets engaged in battle could hardly exist; nothing remains for *A*, therefore, but to bring about a great difference in speed, by attempting, on opening the engagement, to destroy the enemy's smoke pipes by a dense fire from his intermediate battery. If these be destroyed, or damaged, the boiler draft is lessened, the steam pressure falls; and the speed therefore decreases. If the head of the column stops, so must the following ships; in this way, one's own fleet might be able to reach the T position. It is quite possible that, by the development of the maximum intensity of fire at the very beginning of the battle, the opposing tactical formation may be entirely or partly broken up by a shower of hits. Even the slower *B* might do this, in so far as he shoots better.

[*Funnel damage is not important so much because of its effect upon speed, which with forced draft would be but little affected thereby, but because of the effect upon the personnel of the escaping smoke and gases.*]

As the moral effect of the first hits will surely be decisive, it must be accepted that the intermediate battery is still far from having played out its part in naval warfare. On the contrary, the gun of intermediate caliber, which, for example, can fire three

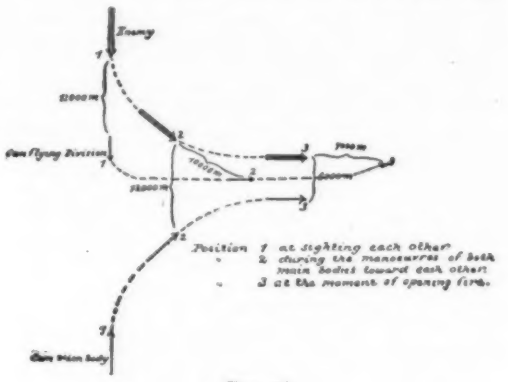

Enemy
Own Flying Division
Position 1 at sighting each other
2 during the maneuvres of both main bodies toward each other.
3 at the moment of opening fire.
Own main body

FIG. 14.

shots (hardened common shell) of 90 to 100 kilogrammes each in a minute, just at the opening of the engagement, even at 8,000 yards distance, will have, not a perforating, but a decisive smashing effect. The high rate of fire of this gun assures a quick determination of the range, by means of which the condition to get the range first is more nearly fulfilled.

Experience has also shown that a battleship with 22 knots trial speed may not be much superior tactically to a ship of the same size with a better battery but with a speed of only 20 knots. Superiority in gun power must be sought; a slower battleship can, by a more accurate and a more rapid fire at the very beginning of the fight, so injure a more rapid enemy that no further use can be made of a superior trial trip speed. The result of this is that, in new construction, too many sacrifices should not be made for speed. It is surely no disadvantage to provide a superior battery for a ship which has from 1½ to 2 knots less speed than that of a probable enemy. For example, the battleship *A*, with a superiority in speed of 2 knots over *B*, will run about 60 meters more than *B* every minute; in ten minutes it will be ahead of *B* by about 600 meters, in an hour by about 3,600 meters; the change is therefore very slow, during which *B*, by turning very slowly, can keep the faster *A* on the same bearing, and even win by more accurate shooting. A superiority in speed of even two knots is far from assuring success. Of two battleships of the same displacement, of which one is two knots slower than the other, the advantage rests with the slower one if it have a correspondingly better battery.

An increase in speed of two knots in a large ship requires an increase of machinery weights of about 600 tons—about the same as the weight of two 30.5-centimeter turret guns with their ammunition.

Superiority in speed is not decisive even from a strategic point of view. Suppose that the coast line of a sea power is 300 knots long, and the enemy's fleet suddenly starts to steam from one end of the coast to the other, it will mean a trip of 15 hours at 20 knots, and 13½ hours at 22 knots. Now, is it better to arrive 1½ hour sooner, or to have a corresponding superiority of gun power in place of this advantage in time? Surely superiority in gun power will be worth more in the following battle than two knots superiority in speed.

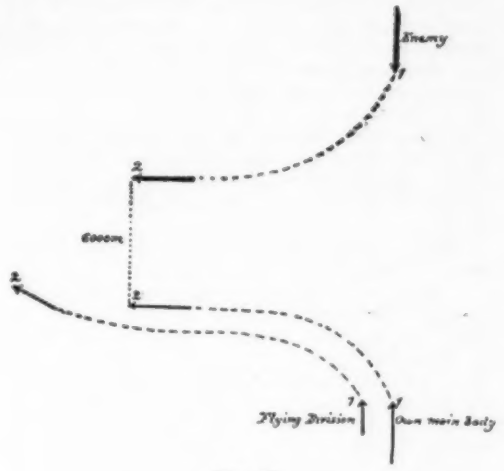


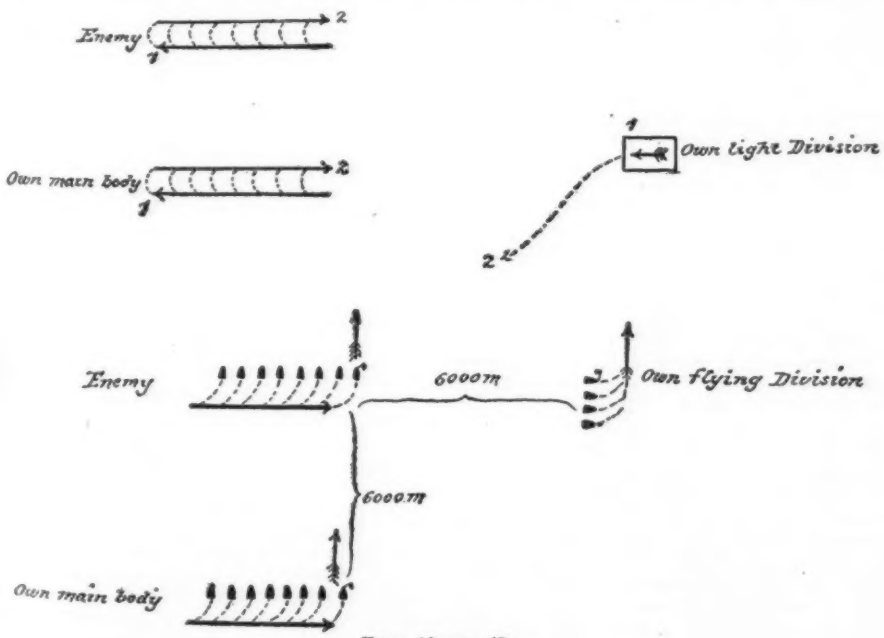
FIG. 15.

However the attack be commenced, whether on opposite courses (Fig. 6), or at an angle (Fig. 7), the opposing fleets will generally find themselves parallel to each other after the preliminary evolutions. By a frontal attack (in line), one has the advantage of turning one's broadside sooner than an enemy approaching in column from the opposite direction; this has the disadvantage, however, of only too easily keeping the commander-in-chief of *A* in the rear, in case *B* in Fig. 9, for example, should turn to starboard at the right time, and thus anticipate *A's* intention.

[*In Figs. 8 and 9 B is capped and must complete his turn before A's gun-fire becomes effective or he will be under a great disadvantage. This illustrates the advantages which a frontal approach may have under certain conditions.*]

Take two fleets *A* and *B*, of which *A* is the faster. Steering parallel to, and abreast of each other, *A* after a certain time will pass *B*, and will try to obtain the T position. If *B* does not turn away, but keeps straight on, and goes ships left about just as *A* has gotten well ahead and means to rake him, the two rear ships will be at the head of the columns, and *B* will now have the advantage in regard to getting the T position. Therefore even here, *A's* superiority in speed gives him no special advantage.

The *A* admiral can employ this maneuver in the example given in Fig. 9, in order to avoid holding a fatal position at the end of his own column; he orders "slow speed," lets *B* get ahead, and goes ships about, whereby he remains in the lead, while the *B* admiral will find himself at the rear of his column.



FIGS. 16 AND 17.

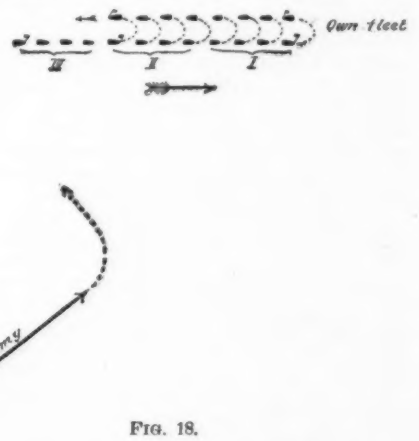


FIG. 18.

[*Whichever fleet turns as suggested is under a tremendous disadvantage during the 3 or more minutes required for the maneuver.*]

Eventually, an important part is played in battle by the rear ships in exact column; therefore just as powerful ships should be placed in the rear as at the head of the column; in all cases, the weaker ships present must be placed in the center, if provision has not been made to group them in a separate formation. It seems essential that the rear ship should be a flagship, as its position is next in importance to that of the guide; therefore it must have the second in command aboard. This also facilitates a frontal attack (in line), as there is now an admiral in each wing.

If we consider the results of the already discussed

tactical evolutions, it is evident that, while maneuvering in exact column on parallel courses, no advantageous tactical position can be gained merely by superiority in speed.

[The author does not take into account torpedo fire, which would certainly be most effective from the leading fleet.]

As the defeat of the head of the enemy's column is the first and chief aim of the attack, such a distribution of strength must be resorted to, in applying the principles of broadside fighting, that the head of the enemy's column will be held in a cross fire. For this, an effort must be made to sustain only a scattered fire from the enemy, while making use of one's own position to pour in a concentrated fire. For this purpose, armored cruisers can be used.

In doing this, however, the guns on the unengaged side of the enemy must not be given any opportunity to fire; one's own division detached to surround the enemy must not go to the unengaged side of the enemy, but must try to obtain a cross raking fire by taking up a position either ahead or astern of the opposing column (for example, as in Figs. 11 and 12).

If the enemy be reported by the scouts, the problem of the armored cruiser division is to drive back the enemy's vedettes and eventually, after the battle with the scouts, to get into touch with the enemy's main body. The armored cruisers ought to have great speed, and if possible, have batteries superior to those of the opposing armored cruisers; therefore, guns of the heaviest caliber should be carried by these ships, of course in less number than on battleships.

The armored cruisers, united in a "flying division," can now prepare for their own attack, as, when the enemy is sighted, they can take up their most favorable battle position.

If the flying division should happen to be on that side of the enemy's main body which lies opposite to the intended direction of attack by its own main body (Fig. 11), it must go, after the enemy turns to starboard (Position 2), or to port (Position 3), either to rear of or ahead of the enemy. The last change carried out by the enemy might be induced by an intention to attack the weaker part of one's own fleet (flying division). In both cases the enemy runs into a cross fire, and the flying division becomes "spotter" for its own main body at the same time; for example, hoisting a single flag might mean "Range too great," a flag of another color "Range too small." In Fig. 11, also in those following. Position 1 shows the situation when the two main bodies sight each other, Positions 2 and 3, the situation on opening fire.

If the armored cruiser division should happen to be on the same side of the enemy as that from which its own main body attacks, it must never go ahead of the enemy after the latter turns away; passing ahead would require a long time; and, in addition, as its course would cross that of its own main body, would result in a masked fire. The flying division could, in this case, attack and rake the enemy from the rear. If, during the course of the battle, the ships go about, it again is ahead of the enemy. The flying division can do valuable service as spotter from the rear also. If the enemy detaches his rear ships to drive off the harassing flying division, he weakens his own main body; besides, the flying division can easily escape this attack on account of its superiority in speed.

If the entire enemy's fleet should turn away from "own main body" eight points, more or less, she will be now flanked by the armored cruisers in her rear (Fig. 12).

Similar conditions hold in Figs. 13 and 14, in which both main bodies sight each other dead ahead; and the flying division, after finishing its scouting work, finds itself ahead of the enemy.

If the flying division be not sent out on scouting duty, it can steam in column abreast the main body (Fig. 15); and, at the very beginning of the engagement, pass ahead in order to rake the enemy's head; to do this, it must have superiority in speed of 5 knots and over. Therefore, while speed is not tactically important to the battleship, it is of great value to the armored cruiser.

The purposely assumed opposing formations in a single column show the risk a fleet runs in not thinking out favorable tactical positions. A fleet is also at a great disadvantage, which has no armored cruisers to shake off the attacking armored cruisers.

[The foregoing arguments suppose one fleet to be superior to the other, since only one has a "flying division." If each fleet has the same number of ships, the one composed only of battleships must be regarded as the stronger. The scheme of spotting by a detached squadron in battle seems utterly impracticable. For a discussion of the possible uses of a detached squadron see "The Fast Wing," United Service Magazine for January, 1907.]

If both fleets have armored cruisers, a separate battle between these divisions is not improbable; this separate battle would probably precede the great tactical battle as a "scouting fight."

Light cruisers and torpedo-boat flotillas take up a position far in the rear before the battle; they serve as a support for their own damaged ships which fall behind, as well as to entirely destroy the enemy's damaged ships which have fallen out. If the battleships go about, these light divisions again take up a position in the rear (Fig. 16). If there be hostile light divisions within the battle area, their chief problem is to destroy them.

It is not improbable that during the action between the two main bodies, separate fights will take place between the cruiser divisions; the battle of Tsushima offers an example of this, during which the Japanese main body fought the Russian battleships while the Japanese light divisions attacked the Russian cruisers and transports.

If, in the first attack, the enemy is caught in a cross fire, he will hardly be able to again escape from this position. Every movement he makes to escape the cross fire is repeated by all of one's "own divisions" simultaneously, following the motions of each division or squadron commander without waiting for a signal, in this way carrying out the plans of the commander-in-chief (Fig. 17). The separate divisions, while remaining true to the principle of concentration of fire in connection with a scattered hostile fire, must not get too far away from each other; and must not take up positions in which they would be firing toward each other. The complete destruction of the enemy's ships which have fallen out must be intrusted to one's own light cruisers; in this way, an increased superiority in fire is obtained over the remainder of the main body.

If, for example, one's own main body, consisting of three divisions, should find itself in a position to rake the enemy (Fig. 18), and the latter should turn toward one's own rear, in order to double on it, it would seem more advantageous for only the two leading divisions to go ships about, and for the third division to keep straight on, thus covering one's own turn by its fire, as firing cannot be kept up during the turn; in this way, a pause in firing will be prevented. When the first two divisions have formed again, the third division joins by a simultaneous turn. It is therefore recommended that the commander of the second division designate the proper place for the third division when the ships form.

[The enemy would never head as supposed, as he would thus be assuming a "capped" position.]

The exact column and the temporary line or echelon arising from simultaneous turns amply suffice for carrying out battle tactics in conformity with the explained principles. If the leading and the rear ships be flagships, they are in the wings during temporary formations.

The only evolutions needed are countermarches and simultaneous turns; extended formations, additional columns, double echelons, wedge formations, double line and squares are rendered unnecessary. Naturally, these battle tactics demand continuous practice in time of peace.

(To be continued.)

THE COLOR SENSE OF THE ANCIENTS.

By DR. CHARLES WILLIAM SUPER.

THE fact that the ancients habitually speak of only four colors is almost proof positive that they did not discriminate more. In addition to the evidence already cited, there is to be added that of painting. What is known of the art of Polygnotus, the earliest of the distinguished painters of antiquity, and a contemporary of Pericles, leads to the conclusion that he used no greater number, according to the ideas of his time. Like all early painters he worked on terra-cotta vases, and on walls, not on canvas. It seems highly probable that throughout antiquity no distinction was made between orange and yellow, nor between indigo and blue, nor between the darker colors that shade into black. Many of the lower races, both at home and abroad, share this defect. Both have also the same liking for what is gaudy and striking. It is probable that the fondness for "loud" colors is a species of survival that may be studied in children and in persons that are color-blind. The latter defect is a species of arrested development, and being an organic defect cannot be overcome. On the other hand, some primitive races are reported to exhibit a very acute color-sense. This mental condition has likewise its analogy among children, some of whom are indifferent to colors, while in others the color-sense shows itself very early. At any rate, modern analogies will not enable us to decide the question for or against any people of antiquity. Two theories have long been held to account for the poverty of terms to designate colors in remote times. The one most in harmony with the evolution hypothesis is that the color-sense has followed the general law of development; the other, that primitive races perceive colors as clearly as we do, but that their languages lack words to designate minor differences. Color-blindness has no connection with mental power in general. It is well known that the celebrated physicist, John Dalton, was not capable of distinguishing more than three colors. Many similar cases are on record. This defect has become known as daltonism or achromatopsia. A more correctly constructed compound would be chromatuphlosis. However, technical terms often lead the philologist to express the same opinion of them that the devil is said to have used of the Ten Commandments, "They are a queer lot." In the language of the Psalmist, "They are fearfully and wonderfully made." Generally speaking, animals make less use of sight than man; all those that have been domesticated select their food by the sense of smell and not by sight. The test may be readily made with blind horses, which are unfortunately not as rare as they ought to be. Birds, on the other hand, depend wholly on the sense of sight, which is remarkably acute.* In ancient accounts of battles, sieges, and pestilence, those gruesome birds that live on corpses are never absent. It may be taken for granted that the problem, How do we see? exercised the ingenuity of the ancient thinkers a great deal. It need not surprise us that they were wide of the mark, seeing that there is as yet no universally accepted theory of vision. But the moderns have learned that color is subjective, whereas the ancients regarded it as objective. Lucretius, who follows the teachings of some of the Greek philosophers, probably of Empedocles, affirms that very thin films are detached from the visible object and impinge upon the eye to produce sight. Aristotle was convinced that there must be some medium between the organ of sight and the object seen by which the sight-process is mediated. Lucretius says that persons afflicted with jaundice see everything yellow because so many atoms of that color fill the orb of sight. He compares the casting away of films or effigies to the cicada that casts off its tunic, or the snake that sheds its glossy vesture and to fire that emits smoke. Much later Locke says: "Since the extension, figure, number, and motion of bodies of an observable bigness may be perceived at a distance by the sight, it is evident that some singly imperceptible bodies must come from them to the eye." Lucretius seems to have observed natural phenomena with unusual care for a Roman, but it was rather their more violent aspects, such as thunder and lightning, earthquakes and waterspouts and floods. The phenomena of rain, hail, and snow could of course not escape his attention. It has been shown above that the ancients, particularly the Greeks, had a very defective perception of colors and that they had very poor eyes for the beauties of nature as displayed in scenery. It may be interesting to trace briefly the growth of this last sentiment, since it is one of the latest phases of evolution. The Greeks were eminently a social people. They laid great stress upon that urbanity which is acquired only by long association of man with man. Greek pedagogy insists that education shall above all things make the gentleman. Greek thinkers were far more interested in their fellow men than in their irrational companions or in the silent creation. It is true Theocritus, and the much later Dio, praise country life, but they lived in an age that was pre-eminently one of books. They commend the simple and unsophisticated manners of those who keep aloof from the haunts of men more than they express delight in their rustic surroundings. They do not like nature so much as they dislike man. Among the Romans, Virgil and Horace follow the same course. They either never leave the city or they stay within easy reach of it. They do as did the usurer whom the latter portrays in his much-read and often-translated second Epode. After enumerating the delights of country life and the various vexations of those who have much to do with men, he ends just where he began—by staying in the city. This praise of rural life reads as if written by one who knew but little about it.—Popular Science Monthly.

* I recently came across the following—how much truth there is in it I do not know: "Red will annoy a turkey-cock as much as a bull, but a sparrow will not let it disturb its mind. But if one shakes a blue rag in front of a caged sparrow's eyes, he will go frantic with disgust. Sparrows and linnets, too, will refuse food offered to them on a piece of blue paper, and dislike the appearance of any one wearing a blue dress. Medium light blue affects them most, but blue serge they scarcely mind at all. Thrushes and blackbirds object to yellow, but will use red or blue dried grasses left about their haunts to build the outer layers of their nests. Yellow grasses they let alone."

A NEW METHOD OF PREPARING ANHYDROUS PROTOXIDE OF LITHIUM.

IN a paper read before the Academie des Sciences, M. De Forcrand describes a new method of preparing anhydrous protoxide of lithium, Li_2O. After giving a *résumé* of the processes which are now used and which are far from satisfactory, the author gives an account of the method he uses and claims that it is much superior. To start with, he uses a nearly pure lithia which is now found in commerce, or a crystallized hydrate of lithium. As to the pure lithia, it contains less than one per cent of impurities, and is a solid matter, coming in plates having a crystalline structure. To obtain the desired oxide, it suffices to place this body in a platinum trough inside a porcelain tube which is heated electrically and traversed by a current of pure and dry hydrogen. Heating to 660 deg. C. the dehydration is rapid at first, then becomes

slower and takes seven or eight hours to be complete. By heating to 780 deg. C. the final result is obtained in one hour. At these temperatures, there is no loss by volatilization, and the weight remains constant. But if we reach 800 or 820 degrees we find a loss of weight due to the escape of the anhydrous oxide. By this process we obtain a pure white substance, non-crystallized and porous, under an arborescent form upon the bottom of the trough. Analysis gives the formula Li_2O corresponding to the pure anhydrous protoxide of lithium. The second method lies in the use of the crystallized hydrate of lithium, $LiOH, H_2O$, this being the secondary hydrate. It is obtained by the author in fine crystals by evaporating a solution of lithia in the cold, in dry air. Such crystals may retain some water, but upon drying in a current of dry hydrogen, they may be obtained in the normal state. Placing this hydrate in a platinum trough and heating as above, at 780 deg. C. in a current of dry hydrogen, he obtains the anhydrous oxide in less than one hour. It has the same appearance as the above, and is almost pure.

VALUE OF SWALLOWS AS INSECT DESTROYERS.

SOME FACTS ABOUT USEFUL BIRDS.

BY H. W. HENSHAW.

THAT insect-eating birds are of immense value to the farmer and the forester is so well known that their protection is now believed to be absolutely necessary to the welfare of any country. But the value of certain kinds in the United States has been recently emphasized through the invasion of the cotton States by a new and destructive insect—the boll weevil. This new pest, despite every effort to stay its march, is spreading at the rate of about 50 miles a year, and sooner or later is certain to infest the entire cotton-producing area—a fact which not only seriously concerns the southern planter, but in its ultimate consequences affects the well-being of the whole country.

Birds are among the natural enemies of the weevil, but by themselves are quite inadequate to the task of controlling the ravages of the pest. The losses it inflicts are of such magnitude, however, that no aid can be safely neglected, especially when so important as the services rendered by birds. As the result of investigations by the Biological Survey, thirty-eight species of birds are now known to feed upon the weevil. Prominent among these are the several species of swallows, including the purple martin.

The martin, the barn swallow, the bank swallow, the cliff swallow, and the rough-wing breed—some of them only sparingly—in Texas and elsewhere in the South. They breed also in the North, but the tree swallow and the cliff swallow—very important members of the group—appear in the South, the former during the spring and fall migration only.

Steps have been taken to acquaint the farmers and other residents of Texas and the remaining cotton-producing States of the importance of increasing the numbers of the local species and of extending the range of certain species in the cotton districts. This may be done by strictly enforcing the laws protecting swallows and by providing additional accommodations for nesting. These steps alone, however, are not sufficient. It is very important also that all of the swallow tribe nesting in the Northern States and migrating through the cotton belt be increased to the limit, more particularly since in late years a steady diminution of their numbers has been noted.

Tree Swallow.—The tree swallow, as is well known, has been persecuted by the English sparrow until it has entirely abandoned many districts where formerly it abounded. Unless a systematic effort be made to reduce the number of sparrows and to protect from invasion the boxes put up for the occupancy of swallows, it is difficult to see how the tree swallow can reoccupy the old territory from which it has been driven, or even long hold its present area. An energetic war on the English sparrow and the careful protection of the swallow domiciles in a few years would result in a complete change of the situation, so far as this, one of the most beneficial of the swallow tribe, is concerned.

Barn Swallow.—The barn swallow formerly was abundant throughout the Northern States, especially in New England. The tightly-built modern barn, however, no longer invites the presence of the barn swallow by affording it friendly shelter, and the birds are becoming scarcer and scarcer. To provide openings in modern barns and to encourage the presence in them of colonies by providing convenient nesting sites are easy and effective methods by which this beautiful species may be greatly increased in numbers. This bird also requires protection from the English sparrow, which in one foray has been known to kill the young and destroy the eggs of a large colony.

Bank Swallow.—The well-known bank swallow, as its name implies, nests in sand banks in holes of its own digging. Some farmers in the Northern States take special pains to protect their colonies of bank swallows from the marauding boy and the prowling cat. Some even take pains to excavate suitable banks on their farms and devote them to the exclusive use of the swallows. Gravel and sand banks are so numerous throughout the North, especially in New England, that at trifling expense the number of colonies of bank swallows may be vastly increased, to the advantage of every farmer North and South, and to that of every nature lover as well.

Cliff Swallow.—The curious pouch-shaped mud structures of the cliff swallow, attached under eaves or to the face of cliffs, are a sight familiar enough in the Northern and Western States, but in the cotton States, save Texas alone, they are wanting, the bird that makes them being exclusively a migrant. The English sparrow persecutes also the cliff swallow; hence, in the North, the bird is much less common than formerly. Under the mistaken idea that cliff swallows are not desirable neighbors, the nests, especially when near houses, are often destroyed and the birds driven away. All birds are more or less subject to parasites, especially when nesting, but the parasites are not bedbugs nor the kinds obnoxious to man, and no one need banish the swallows for fear of trouble from this source. In Germany the presence of swallows around houses is so much desired that artificial nests made of clay or other material are put up in order to attract birds by saving them the labor of constructing their own domiciles. No doubt our own cliff swallows would be quick to respond to a similar offer of ready-made dwellings, rent-free, and in this way the range of this extremely useful species might be materially increased. The cliff swallow is one of the most indefatigable insect destroyers extant, and every motive of patriotism and humanity should prompt communities among which they live to protect and foster them in every possible way.

Purple Martin.—This, the largest and in many respects the most beautiful of all our swallow tribe, is the most local and the least numerous. In New England, and perhaps in most of the Northern States generally, this fine bird is steadily diminishing in numbers. The English sparrow often takes possession of its boxes, ruthlessly kills the young martins or throws out the eggs, and usually succeeds in routing the colony and appropriating the boxes. When measures are not taken to abate the sparrow nuisance in the immediate vicinity of martin colonies, the usual result is that the martins are forced to abandon their houses. The habit of putting up houses for the accommodation of martin colonies is not as common in the North as it formerly was, and to this indifference to the martins' presence, to persecution by the sparrows, and to losses due to the prevalence of cold storms during the nesting season, no doubt, is due the present scarcity of the bird.

Simply to put up martin boxes in localities where the birds do not now live may or may not ultimately result in the formation of new colonies, for the martin is conservative by nature and loves its birthplace too well to colonize strange localities until forced away by lack of accommodations in the old home. More active measures, therefore, have been suggested to induce colonization, particularly the transfer at night of one or more martin houses, with both parent birds and nestlings, from their old homes to new ones.*

Having their nestlings to care for, the old birds probably will not always desert them, but are likely to resume parental duties in the strange neighborhood, especially if the old home is far distant. The theory is that the following spring on their return from the South the young martins, and possibly their parents, will go back to the new home. As the young can be raised by hand without serious difficulty, it may prove easier to start the new colony with nestlings alone, feeding them on meal worms, grasshoppers, and the like. Six or eight pairs can well be spared from a strong colony without unduly weakening it. This method promises well, and if the experiment can be tried from year to year, even on a small scale, a gradual increase in the number of martin colonies is likely to result and new centers of distribution to be formed.

From the standpoint of the farmer and the orchardist, perhaps no birds more useful than the swallows exist. They have been described as the light cavalry of the avian army. Specially adapted for flight and unexcelled in aerial evolutions, they have few rivals in the art of capturing insects in midair. They eat nothing of value to man except a few predaceous wasps and bugs, and in return for their services in destroying vast numbers of noxious insects ask only for harborage and protection. It is to the fact that they capture their prey on the wing that their peculiar value to the cotton grower is due. Orioles do royal service in catching weevils on the bolls; and blackbirds, wrens, flycatchers, and others contribute to the good work; but when swallows are migrating over the cotton fields they find the weevils flying in the open and wage active war against them. As many as 47 adult weevils have been found in the stomach of a single cliff swallow.

What may be termed the interstate relations of birds are not always as simple as in the case of swallows. Some birds are most desirable summer residents of Northern States, but when migrating greatly damage certain crops in the Southern States. Not so with the swallows. Their beauty, their graceful flight, and their sociability insure them a welcome everywhere and endear them to every lover of nature. Their esthetic value, however, great as it is, is not so important as their economic worth, so constant and effective is the warfare they wage against the insect hosts which but for them and other avian benefactors would render successful agriculture impossible. To the Southern States may safely be intrusted the duty of protecting and augmenting in every possible way the numbers of resident birds that prey upon the boll weevil. But it is for the Northern States to aid the good work so far as lies in their power. An enlightened patriotism knows no State boundaries. The insect enemy of the farmer of either district is the enemy of the common weal, and only from co-operation can come a full measure of success.—Bulletin No. 56, Bureau of Biological Survey, U. S. Department of Agriculture.

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* This experiment was tried in the zoological gardens of Philadelphia in 1889 by Mr. Robert D. Carson, who, by means of a trap house, secured a colony of nine pairs with 32 young from the grounds of Mr. Josiah Hoopes, of West Chester, transporting them the distance of about 20 miles by train at night. When released next morning the old birds deserted the young and returned to West Chester. The temptation of the old home so close by proved too strong even for parental affection. Most of the young, however, were successfully raised by hand feeding, being fed chiefly cockroaches, grasshoppers, crickets, meal worms, and "prepared food." This is a mixture intended for insectivorous birds, and according to Mr. Carson was well liked by the nestlings and agreed well with them. It consists of "dried and ground beef heart, maw meal, ground zweiback, boiled and mashed white potatoes, grated raw carrot, and grated hard-boiled eggs." Probably any similar mixture would answer equally well. A small colony resulted from this experiment which would probably have proved permanent but for the fact that additional houses were put up in West Chester, and after two years the colony deserted to the old neighborhood. Though only temporary success was achieved, the experiment is encouraging and points the way to ultimate success. For the above facts I am indebted to Mr. Charles J. Pennock, of Kennett Square, Pa.

Consul E. H. Dennison writes that a German firm has recently introduced into Bombay a portable fan, which is propelled by a hot-air engine and which is destined to have a large sale in India. He says: Owing to the intense heat which prevails in this country during most of the year, fans of some kind are a necessity to the comfort of Europeans, and their offices, shops, and residences are all equipped with the old-fashioned swinging screens known as "punkahs," which consist of a piece of cloth or matting stretched over a rectangular frame hung from the ceiling and kept in motion by a servant at the end of a cord. Wherever electricity is introduced, these are generally superseded by electric ceiling fans. The natural field for the hot-air engine fan would be in localities where there is no electric power, but it has been found that it can compete with the electric fan in the latter's own field, owing to the extreme cheapness of the cost of its running, which is about one-fifth of that of the electric fan. The fan is propelled by a hot-air engine, the heat being generated by a kerosene lamp which holds about one quart of oil, sufficient to keep the fan running for over twenty-four hours. To the lamp is attached a small glass chimney, which fits into a larger metal chimney connected with the engine. Upon the top of the engine is hung the fan, similar in shape and size to the ordinary electric fan, whose speed is governed by the size of the flame; that is, to reduce the speed the flame is turned down, and to increase it the flame is turned up. The whole outfit weighs about thirty pounds, and sits upon a small stand, raising the level of the fan proper to that of an ordinary desk. It is fitted with handles, and can be easily moved to any portion of the room or house desired.

ELECTRICAL NOTES.

Occasionally prophecies have been made by visionaries, as well as others, that the day of the steamship will soon be over, and its place will be taken by an electrically propelled vessel. This prophecy was given more weight than usually attaches to such forecasts when it was reiterated by Sir Hugh Bell, in his presidential address delivered recently before the Iron and Steel Institute, of Great Britain. He said that the old coal-burning machinery would be displaced, and that vessels with little or no machinery on board, with barely any crew, will speed on their way, drawn by the electric force generated at Niagara and transmitted over the ocean by wireless telegraphy. He thought, strange as this forecast might seem, it was no more incredible than what had happened during the preceding century. The prophecy does seem somewhat optimistic at the present time, particularly if one would apply to the process contemplated our present knowledge of wireless transmission of power, even when employed for such infinitesimal work as affecting a delicate wireless receiver. But, theoretically, the thing is not impossible, and we can only hope that it will become yearly more probable, and that eventually the ocean steamer will be as independent and as simply controlled as a trolley car.—Electrical Review (N. Y.)

Dr. Haanel, Dominion Superintendent of Mines, in a report to the Minister of Mines respecting the thermo-electrical experiments carried on by him at Sault Ste. Marie for smelting of iron ores by electricity, states that a 10,000-horse-power plant capable of producing 120 tons of pig iron per day of twenty-four hours would cost $700,000, and that, allowing for interest and depreciation of plant, the cost of smelting would be $2.43 a ton. Adding the cost of ore, charcoal, labor, electric energy, and other running expenses, he estimates that a ton of pig iron could be made for $10.69. The electric smelting works now being erected at Welland, Ont., are expected to produce from 35 to 40 tons of pig iron a day. The report lays much stress upon the possibilities of developing Canada's many iron deposits by means of water-powers which are to be found throughout the Dominion, pointing out that many water-powers exist in both the provinces of Ontario and Quebec which are surrounded by iron ore fields, but in localities ill adapted for the application of electric energy for any other purpose and which could be developed to furnish an electric horse-power for from $4.50 to $6. With such a price for the energy required, the small consumption of electrode, the cheapness of the ore employed and the peculiar excellence of the iron produced, electric smelting of iron ores in Canada in properly constructed furnaces, using charcoal or peat coke made from Canadian peat bogs which exist everywhere and of enormous extent, may be pronounced commercially feasible.

At a recent meeting of the American Institute of Electrical Engineers, Mr. D. McFarlan Moore described in a paper the latest form of tube lamp with which his name is associated. An interesting feature of the lamp as now constructed is an automatic feeder valve, which serves for maintaining the vacuum at the desired degree. Experience has shown that when no provision is made for the supply of gas to the tube the vacuum tends to become higher in time, due to the fact that a portion of the residual gas within the tube is absorbed during the operation. The resistance of the gaseous conductor within the tube is a minimum for certain degrees of exhaustion, and it increases rapidly as the exhaustion increases, or as it decreases, as was shown by an accompanying curve. The critical degree of vacuum at which the conductivity is a maximum is shown at a certain point on the curve, while the tube is normally operated at a lower vacuum. It will be observed, therefore, that as the electricity uses up the gaseous conductor the vacuum becomes higher, the conductivity improves, and a greater current flows through the circuit. Use is made of this characteristic of the vacuum tube to maintain the vacuum at the desired degree. A feeder valve is arranged to permit air or other gas to enter the tube just when it is needed and in an entirely automatic manner. This valve is in reality a mercury seal operated by means of an electromagnet whose coil is connected in series in the supply circuits. The mercury serves to seal the pores of a carbon plug. The action of the solenoid is to lift a concentric glass tube partly out of the mercury, the surface of which falls and thereby causes a minute tip of the conical-shaped carbon plug to be slightly exposed for a second or two, and an extremely small quantity of air or other gas filters through the porous section of the plug and finds its way into the vacuum tube proper. In normal operation the carbon tip is exposed for about one second every minute. When the air is admitted, the resistance of the tube increases and the current through it decreases, and, therefore, the feeder magnet becomes weakened and the air or gas inlet is closed. The luminous efficiency of the tube lamp depends not only upon the value of the current at which it is operated, but varies with the nature of the gas used in the tube. Carbon dioxide gas gives a perfectly white light, while the light from nitrogen gas has a pink tint. When it is desired to feed the tube on nitrogen, air is made to pass through a small iron cylinder containing a supply of phosphorus. In order to prevent more air than necessary from coming into contact with the phosphorus, the air is required first to pass through a small mercury trap. When the tube is to be fed with carbon dioxide gas, the gas is generated automatically by means of the action of hydrochloric acid on marble.

SCIENCE NOTES.

In the main reef of the Reitfontein mine of the Witwatersrand are scattered numerous rounded pebbles of pyrites, which are believed by Mr. C. B. Harwood to be pseudo-morphs. They occur in what is known in consequence as the Buckshot Reef. They exhibit radiate fibrous structure, and are probably of concretionary origin. At the Crown Reef mine a few "pebbles" of pyrites, some as much as an inch in length, occur in a narrow band of conglomerate at the contact of the reef with a basic dyke, but in this mine many of the "pebbles" are of calcite, and were believed by Mr. J. Huntz to be due to the replacement of quartz by calcite. In the case of the pyrites pebbles, it is conjectured that the mineralizing solutions which deposited the pyrites (together with some if not all of the associated gold) ascended along the fractures due to the intrusion of the dyke, and found an easy course along the small conglomerate bed, where they replaced some of the quartz pebbles with pyrites, being kept up by a band of shale underneath the conglomerate.

It appears that the rubber tree can be cultivated in Sicily under very favorable conditions, according to a report made not long since by Prof. Borzi, chief of the Botanical Garden of Palermo. The report relates to the cultivation of the *Ficus elastica*. The rubber tree here finds the same conditions which occur in its native region, at least to a considerable extent, and the average temperature of Sicily is about equal to that of Sikkim and Khasia. Specimens planted in the open air showed a hardy growth during the last few winters, even when they were not housed under special shelters. When under the climate of Sicily the rubber tree continues to grow even in winter and to develop its branches and flowers, which proves that it accommodates itself to the change of climate. As regards the lack of rain, this drawback can be overcome by artificial irrigation. Analyses made upon the specimens showed the presence of rubber in the sap of the plant, and it is abundant and of good quality. Experiments made at Palermo showed that we may count upon one pound of rubber per tree at the start of the cutting, that is, when the tree is at least ten years old, and this amount increases with the age at the rate of 0.2 pound per year's growth.

If a lighted candle be placed in front of a concave mirror between the focus and the center of curvature, a real inverted image of it upon a screen can be obtained in a definite place beyond the center of curvature. If the candle is placed so that this image is fairly distant, any one looking into the mirror will see a second image of the candle apparently behind the mirror. Now, since the rays from any point of the candle must be converging after reflection to a point on the real distant image, it follows that the image seen in the mirror must be seen by means of converging cones of rays. Any eye which sees this image with anything like perfect definition must be able to adjust itself to more than infinitely distant objects. Short-sighted people will not see the image except as a blurr of light. But it is astonishing how well-defined it can appear. And it is still more astonishing that, as far as I am aware, no textbook contains any account of this phenomenon. Instead of a candle, the observer may examine the image of his own face in this way, and it is interesting to observe the changes as the observer draws close to the mirror, when, of course, the usual, erect vertical image is obtained. Those interested in this question are recommended to draw the rays, in various cases, by which the images are seen.

A set of ancient Pan pipes was brought to light not long since at Alise-Sainte-Reine in France, supposed to be the site of the ancient Alesia. They were shown at a meeting of the Académie des Inscriptions et Belles Lettres at Paris. This object was found at the bottom of a well seventy feet deep, and above it was a bronze object of the period of Alexander Severus, which gives an idea of the date. It is a thin wood tablet about 4½ inches long with one face smooth and the other bearing geometric designs. A hole in the bottom allowed a cord to be attached. In the upper edge were bored seven holes in the thickness of the wood and these holes had unequal depths. An eighth hole is seen in a broken part at one side. Inspection of this latter makes it clear that the holes were made with a red-hot iron rod pointed at the end. The holes are cylindrical, but they end almost in a point at the bottom, the depth varying from 3 inches to 1.4 inches. As will be seen, the specimen differs from the ordinary Pan pipe *syrinx* such as we see cut on stone or otherwise shown, or described in texts. The latter was made of reeds assembled by wax or by bands. The present specimen gives a very high-pitched sound, as was general in this class of instrument. As to the musical scale which it used, it was determined by the formula for sound tubes and also by ear by several expert musicians. Allowing for some slight discrepancies, no doubt due to the age of the pipe, the scale appears to be the hypophrigian. Previous discoveries gave us ancient flutes, trumpets, pieces of lyres, and we now have the Pan pipes to add to the series.

TRADE NOTES AND FORMULÆ.

Bouillon Soup Tablets.—Finely chopped meat, completely freed from fat, with a little water and some salt, is cooked in a Papin pot until a sample taken out sets into a solid mass. The addition of gelatine to the extent of 5 per cent of the meat quantity, accelerates the process. The fluid mass is ladled hot into small tin molds, in which it solidifies into tablets, which, like chocolate tablets, are wrapped in tinfoil or paraffine paper.

Blood Albumen.—Production of a light-colored product, containing globulin from blood. The blood coagulum, obtained in any manner, is extracted with ethyl alcohol, methyl alcohol, or acetone, with admixture of 0.5 to 1 per cent of an acid, an alkali, or an alkaline carbonate, until the greater portion of the hematine and coloring constituents have been removed. A complete decoloration cannot be effected by prolonged extraction, but can be accomplished by distributing the product obtained in water and bleaching it by the addition of a suitable bleaching medium, such as chlorine, permanganate of potash, or peroxide of hydrogen. In this condition the albumen obtained can be employed for finishing tissues, for the production of coatings, or as nutriment. With regard to the recovery of the extraction fluid, distillation can be avoided by precipitating out the dissolving agent, i.e. the acid, the alkali, or the salt, by any of the well-known methods, with the aid of a suitable chemical reagent. The hematine remaining in solution is at the same time thrown down. It is then only necessary to separate the fluid from the deposit by filtration, in order to be able to use it again for extraction purposes.

To Make Quickly-Drying Varnish.—It is now considered probable that the process of preparing varnish is based on the one hand on the polymerization of the oil, induced by the raising of the latter to a higher temperature, and on the other, on its oxidation. The more unsaturated fatty acids the oil contains, the more powerful is the oxidation; the oxygen not only saturates the free substances, but also forms acids, in which the combined oxygen is placed between the carbon and the hydrogen. Together with vigorous oxidation a splitting off of carbon occurs, resulting in the formation of volatile gaseous products, such as carbonic acid, carbonic oxide, acetylene, etc. It is moreover stated in literature treating of these subjects that the formation of anhydrides has likewise been observed in long-continued oxidation. The oxidation of the oil is therefore a very complicated process.

Quickly-drying varnish can be prepared otherwise than by means of the substances ordinarily employed for transferring oxygen (plumbic and manganic oxides) by using ammonic nitrate, which when heated to 285 deg. C. decomposes according to the formula $NH_4NO_3 = N_2O + 2H_2O$, i.e., in addition to water, nitrous oxide is formed, which, like oxygen, has a powerful oxidizing action.

Ammonic nitrate, finely powdered, is added in small quantities, about ½ gramme at a time, to the oil heated to 270 deg. to 280 deg. C. (during oxidation the temperature rises spontaneously a little, and care must be taken that it does not rise above 300 deg. C.) and the mixture constantly stirred. The liberated steam renders the stirring of the oil necessary, while the nitrous oxide gases are dissolved in the oil and induce the oxidation. Toward the end of the oxidizing process the oil becomes darker and acquires a peculiar odor.

TABLE OF CONTENTS.

PAGE

I. ARCHÆOLOGY.—Excavations in Crete.—9 illustrations. 47

II. AUTOMOBILES.—A Self-propelling Searchlight.—By L. RAMAKERS.—1 illustration. 36

III. CHEMISTRY.—Some Facts About Dynamite. 36
A New Analysis of Bread and Wheat. 39
A New Method of Preparing Anhydrous Protoxide of Lithium. 40

IV. CIVIL ENGINEERING.—The Saint-Michel Station of the Paris Metropolitan.—4 illustrations. 40

V. ELECTRICITY.—How to Construct a Simple Wireless Telephone.—By A. FREDERICK COLLINS.—6 illustrations. 37

VI. MECHANICAL ENGINEERING.—A Novelty in Floating Cranes.—By F. C. COLEMAN.—1 illustration. 36

VII. MINING AND METALLURGY.—Autogenous Welding of Metals.—By ERNEST SCHNEIDER. 39

VIII. NATURAL HISTORY.—Value of Swallows as Insect Destroyers.—By H. W. HENSHAW. 42

IX. NAVAL ARCHITECTURE.—Gun Distribution Aboard Modern Battleships.—18 illustrations. 44

X. OPTICS.—The Color Sense of the Ancients.—By Dr. CHARLES WILLIAM SUPER. 46

XI. TECHNOLOGY.—Rejuvenation of Worn-out Flies. 39
Preparation of Moth-exterminating Powder. 41
The Art of Galvanizing.—II.—By ALFRED SANG. 40